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पुस्तकालय
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PROCEEDINGS OF THE ELEVENTH INDIAN SCIENCE CONGRESS.

The Eleventh Annual Meeting of the Indian Science Congress was held in Bangalore from January 14th to 19th, 1924. After the Chairman of the Local Committee, Dr. B. N. Seal. Vice-Chancellor of the University of Mysore, had read a message of welcome from the Patron, His Highness the Maharajah of Mysore, G.C.S.I., G.B.E., the President, Dr. N. Annandale, C.I.E., F.A.S.B., delivered his address.

Presidential Address.

Before I read my address I have a sad duty to perform. Since we last met we have lost one of the most prominent and the most energetic of our founders—a loss which is personal to many and common to all of us. Sir Henry Hayden was killed some months ago in pursuit of his favourite recreation, mountaineering in the Alps, with which he combined invaluable scientific observations. He was one of the little band which inaugurated the meetings of this Congress, and he presided at the meeting at which preliminaries were settled. He might have been President more than once had he wished. He was a man of wide sympathies and of great generosity, but perhaps his greatest quality was the keenness and determination with which he overcame difficulties in pursuit of his scientific aims. No trouble was too great for him to take, whether it was his own department, the Congress or his own work that was involved. In 1915, in the midst of overwhelming war work, he travelled all the way from Delhi to Madras and back in order to be present at the meeting of the Congress for a single day, and this was typical of all his life and work.

I stand before you this evening in a very difficult position, as a substitute for a great personality. As you all know, Sir Asutosh Mookerjee was chosen to preside at this meeting, but unfortunately the state of his health has obliged him to retire at the last moment and at his request I have assumed the prophetic mantle. Some years ago a paper with elaborate illustrations was to be published in the "Records of the Indian Museum." The author had taken the manuscript away from Calcutta for final correction and had failed to return it, but the plates were ready and the date of the year, which was drawing to a close, was printed on them. "What are we to do?" I said to my assistant. "The plates are dated, the year is nearly done and we have not the paper." "Sir,' he promptly replied, "could you not provide a paper for the plates yourself with your facile pen ?" A facile pen is a dangerous weapon for a scientific man to wield, and I think my assistant's remark was almost a libel. Even if I have the pen of a ready writer, to reduce what I have written to shape implies long, continued and copious correction. In this address anything of the kind has been impossible. You must, therefore, forgive its lack of form and polish.

The first difficulty which met me was to choose a subject; many different projects came into my mind confusedly;--a discourse on the Negritos, a consideration of the present state of zoology in India, a sermon on the organization of science in a bureaucratic country, and many other notions; but, greatly daring, I have decided to address you on the wide subject of "Evolution Convergent and Divergent"—a subject over which I have pondered for many years, though I had not intended to discuss it in public so soon.

EVOLUTION CONVERGENT AND DIVERGENT.

In the brief time at my disposal for the preparation of this address it has been impossible to look up references or to re-read even familiar or comprehensive works. I have had to rely almost entirely on my own experience, to cite instances that have come under my own observation, and to express my own views as such, whether they coincide with or are opposed to those of other biologists. As my experience has extended over nearly twenty-five years in the tropics and has included also some of the sub-arctic islands of the North Atlantic, this course is perhaps justified, apart from the peculiar circumstances of the case.

It is always well to begin a discourse on any scientific subject, however simply it is to be expressed, by precise definitions.

Definitions.

Convergent Evolution may, in my opinion, be accepted as having occurred *when living organisms not related in general structure (or if related, not of precisely the same origin) manifest similarities either in particular organs, in general facies or in instinct, provided that these similarities are directly correlated with special functions or with a similarity of environment.*

Divergent Evolution, on the other hand, may be accepted as having occurred *when organisms related in general structure exhibit in the same or a similar environment different modifications in structure or form or instinct, and these modifications are correlated with the same elements in the environment.*

Convergent Evolution.

A special nomenclature has been invented for the different kinds of convergent evolution, but I need not trouble you with it, for the types on which I wish to lay most stress hardly come within the bounds of this nomenclature; or rather must be considered here from a somewhat different point of view from that usually adopted at the present day. I must confess myself a naturalist rather than a morphologist, a follower of the old school of Darwin, who relied in the first instance on the careful and laborious compilation of data from all sources, and only as a secondary matter on experiments carried out, necessarily on but a few species, in the laboratory or the garden-plot. I must dissociate myself completely from those who believe that environment has no bearing on heredity, or maintain that no biologist should study the phenomena of wild nature until he can first explain the reproductive behaviour of a single species of plant growing under cultivation.

Explanations are always wearisome, but I have been unable to avoid those I have given, if I were to make the scope of my address clear either to a general scientific audience or to experts in the study of evolution.

The stock instance of simple convergence given in all the text-books is that of the resemblance in general form and muscular structure between a greyhound and a race-horse, both animals adapted for speedy running. It would not be difficult to imagine a better example; for both animals have been produced, not through natural evolution but by selective breeding. There would, indeed, be no difficulty in finding innumerable natural instances of a similar nature and equally convincing, for it is a well-known fact that animals which lead similar lives frequently resemble one another in certain respects. A better example than that of the greyhound and the race-horse would be that of the true chameleons, which from a zoological point of view belong to a different group from the lizards, and the bush-lizards of the genus Calotes which are commonly called chameleons in India. But I will not waste your time over elementary instances of the kind, for I wish to draw your attention particularly to more complicated cases in which whole groups or associations of animals resemble other groups or associations living in the same or similar conditions of physical environment, or of food-supply, or of special dangers. Such instances may be divided for the purpose of this address into three main categories, namely: (1) instances in which different groups of animals resemble one another as groups, (*a*) as a general rule or (*b*) in peculiar circumstances; (2) instances in which different faunas or associations resemble one another in different types of environment in which there are certain factors in common; and (3) instances in which both sets of phenomena occur in complex inter-relation.

As an example of one group of animals resembling another in all circumstances as a result of convergent evolution, I choose a case familiar to all entomologists, that of the ants and the termites.

Ants and "White ants."

To the ordinary man ants and termites are to be distinguished only by colour. Termites he calls "white ants," because they are pale and soft. But to the entomologist a termite is as different from an ant as either is from a beetle or a butterfly. Their whole structure, external and internal, is different, and whereas the ant is hatched as a helpless grub and undergoes a complete metamorphosis, the termite is hatched active and not altogether unlike its parents. It is with the resemblances between the two groups, however, and not with the differences that we are here concerned.

The primary fact in these resemblances is the gregarious instinct, and this probably originated in the offspring of a single pair of animals keeping together as they become mature instead of scattering in search of food. The gregarious instinct is of course by no means peculiar to ants and termites; we find it in wolves and in man, in many birds and fishes and crustaceans; but it is only in the insects (apart from man) that this instinct has reached heights which may be called political, and its highest manifestations are to be found in the termites and the ants. These two groups of insects—if you will forgive me speaking half metaphorically and making a point by the use of language which some would call grossly anthropomorphic—these two groups of insects discovered, long before the evolution of man, the benefits both of eugenics and of socialism, and were able to make use of this discovery because they were not hampered by the vagaries of human personality. They evolved a state of society in which only certain individuals were capable of reproducing their kind, while every individual worked for the benefit of the community and not himself, and only performed the particular kind of work for which he was physically and mentally fitted. The extraordinary thing is that so elaborate and so perfect an organization should have come about independently in two entirely different groups of insects and that it should have been perpetuated in both along parallel but independent lines.

In both ants and termites the males and females are as a rule quite distinct physically from the workers, while in all termites and in many ants a soldier caste has been evolved distinct again anatomically from both workers and normal males and females. The convergence of the two groups, though perhaps primarily psychological, is thus definitely anatomical as well. I need not enter into details, but you are all familiar with the fact that in both groups large numbers of winged forms are produced periodically, while the majority of individuals of any community are wingless. The winged forms are the males and females, the wingless forms the workers and soldiers.

I have chosen this instance of the ants and the termites as my first illustration, not only because of its familiarity but also on account of its complexity and because it includes a psychological as well as an anatomical element, for it is an error to think that evolution is only anatomical or physical. Physical peculiarities in any animal organism are probably associated invariably with psychological peculiarities.

I do not mean to imply for a moment, however, that ant or termite society was originally organized like human society by conscious or subconscious individual effort, for I believe that it came about along a different line of evolution. I would rather point to the different methods in which a social organization so like and yet so unlike as that of man and those of the insects has been evolved. In both evolution has been at work; in the insects it has run in a purely social direction so far as psychology is concerned but has been accompanied by profound anatomical differentiation between the different individuals of the brood, while in man it has been brought about by a perfection of mental individuality. Evolution itself, moreover, seems to me not so much a force as a method, a way in which things occur, not a power that makes them occur.

Molluscs of certain recent and ancient lakes.

Let us now take a somewhat simpler instance in which no psychological element is patent, namely that of the resemblance between the living water-snails of the great lakes of Yunnan, those of the much smaller lakes of the Shan Plateau and those that lived in the tertiary lake-basins of Eastern Europe. To make the matter comprehensible I will discuss in the first instance only the species of one family, the Viviparidae, members of which still live in all these countries and have assumed highly peculiar forms in all of them at one period or another.

Species of Viviparidae are found all over the world except in South America and Central and South-Western Asia and the family has great antiquity in geological time. In the vast majority of the species both of the present and of past epochs the shell is or was practically smooth, but in all the lakes I have mentioned forms have been evolved in which it was ornamented with spiral ridges more or less definitely broken up into series of knobs, scales or spines. At first sight shells in which this has occurred are very similar, whether they be from recent lakes in Western China or in the Shan States or from the Plaistacian lake-beds of Slavonia, Dalmatia or the Levant, but on closer inspection constant differences are found. In those from the Shan States the inner edge of the mouth of the shell is provided with a broad, flat, highly polished plate, which is represented in those from Yunnan and from Eastern Europe merely by a narrow ridge. When a series of recent species from the Shan States is compared with one of similar fossil forms from Eastern Europe it becomes evident that while in the Asiatic species there are invariably three main ridges on the shell, in most of the European species there are only two. In this respect there is no difference between shells from Yunnan and those from the Shan States. Further, in the embryonic shells of both Asiatic series three rows of minute pits corresponding to the three ridges on the adult shell can always be detected, while on the two-ridged fossil European shells there are only two rows of these pits. The fact is of importance because we know that in all living forms of the family whether they have smooth or ridged shells, three rows of pits are present and correspond to rows of minute hairs in the living shell, and that these hairs are moulded by definite structures on the edge of the snail's mantle. There is thus evidence that the soft parts of the fossil species as well as the shells were different from those of both sets of living Asiatic species and also, so far as we know, from all living members of the family.

In the uppermost layers of the Plaistacian beds in which these highly sculptured shells occur in Eastern Europe we find a few species with three instead of two ridges on the shell, but these appear to represent merely the last stage of evolution of shell-sculpture in this series.

We are fortunately in possession of a remarkable series of living and fossil forms illustrating this line of evolution in all three series, in that of the surviving species in Yunnan, in that of the surviving species in the Shan States and in that of the extinct species in Eastern Europe. In each series the form that must be nearest the ancestor of the series has the shell smooth or nearly so, but the ancestral representative of each series is quite different from that of either of the others. The earliest representative of the Shan forms has the peculiar plate on the inner edge of the mouth of the shell well-developed, while that of the European series differs greatly in shape and facies from that of the Chinese series.

So far as we have gone at present in consideration of the lake-snails of Western China, the Shan States and the tertiary beds of Eastern Europe, we have been dealing with a single family of animals and with closely related forms in that family. The three series, however, belong to different genera, the Shan series to Taia, the Chinese series to Margarya and the European series to Tulotoma. All these genera can be traced back to tertiary ancestors. Taia and Margarya survive in their respective lakes, while Tulotoma, which apparently became extinct in Europe before the end of the tertiary epoch, survives in North America. Its living representatives have three rows of tubercles on the shell, which is still more highly sculptured than that of any fossil form.

All three series lived or live in lakes eaten out of limestone by the action of water, in a temperate climate and in water containing a relatively large amount of salts of lime and magnesium. There were also, in all probability, other common factors in their environment of which we know as yet little or nothing.

Most writers on evolution draw a distinct line between the resemblances due to convergence in related forms and those produced in a similar way in widely different groups; but it all seems to me a matter of degree. We would naturally expect that similarities would be more easily produced in allied species than in those widely different in general structure, but I am doubtful whether, as a matter of fact, convergent evolution is actually commoner between related than between very distinct organisms. In any case the resemblances between the water-snails of the three sets of lakes are by no means confined to a single family. The Viviparidae of these lakes can be discussed more fully than any other family represented in their fauna, because we have much more information about them.

Put briefly, the facts (or some of the facts) about the other families are as follows: In the lakes of Yunnan a peculiar endemic family of snails is found for which I have recently proposed the name Delavayidae. This family consists of four genera the shell of each of which closely resembles that of a genus found fossil in the Kainozoic beds of Central and Eastern Europe. These beds are perhaps of a slightly different period from those in which Tulotoma is abundant. Unfortunately we have little or no information as to the ancestry of either the Delavayidae or of these fossil genera and it is impossible, therefore, to be quite sure that the resemblance between them is not due to actual relationship. The analogy of the Viviparidae would suggest that it has come about through convergent evolution, but analogy by itself is not proof of convergence. Other genera of water snails occur in China which have a remarkable resemblance to certain tertiary forms from Europe and one of these has been found also in a tertiary deposit in the Shan States together with a species of the Delavayidae.

A clearer instance of convergence is, however, given us by the Plaistacian beds of the island of Cos, which lies off the coast of Asia Minor. In these beds there is a good evolutionary series of Tulotoma in many respects identical with that of Slavonia and Dalmatia, and according to Edward Forbes there is also a parallel series of Neritina, a mollusc belonging to a different order from the Viviparidae. In the older members of this series the shell is smooth, but in the upper beds spiral ridges appear exactly as they do in Tulotoma.

I cannot pursue the ramifications of this complex of convergence and genetic relationship further, but I trust that I have at least demonstrated that it is not so simple an illustration of my subject as it seems at first sight to be.

We may now consider an example of complicated convergent evolution in the second category I have defined, namely, that of resemblances in different faunas or associations living in different types of environment which nevertheless have certain factors in common. I owe this illustration to my colleague Dr Stanley Kemp, but have verified the facts by my own observation.

The fauna of Gangetic creeks and that of the deep sea.

While dredging in the creeks of the Sunderbans some years ago Dr. Kemp, who had had great experience in deep-sea dredging, noticed that the animals brought up in his trawl in quite shallow water bore an extraordinary superficial resemblance as a whole to those commonly dredged in the sea from depths of about 500 fathoms. The resemblance was due in the first instance to their colouration, for both fishes and prawns were either of a dull white colour or else were marked with a deep pink or red, and this is also a peculiarity of a large proportion of deep-sea organisms. On a closer examination further resemblances of a structural kind became evident. The chief of these were the small size of the eyes of many of the fishes and the production in both fish and prawns of long, slender, often thread-like structures which were evidently organs of touch. The degenerate eyes and the possession of feeler-like organs are equally characteristic ot deep-sea animals.

One or two specific examples may be described briefly. Among the common fish of the creeks of the Gangetic delta one of the best known and most abundant is the Topsi or Mangoe Fish (*Polynemus paradiseus*). This fish has smaller eyes than the majority of its relations, from which it is also distinguished by the long, slender, tapering lobes of its tail-fin and by the fact that it possesses several thread-like filaments proceeding backwards on both sides from the anterior lower part of its body. Some of the filaments greatly exceed the whole fish in length. Precisely the same characters are found in a genus of deep-sea fishes named Bathypterois, which belongs to an entirely different family. The long filaments in the fishes of this genus, moreover, arise not from the lower part of the body but from just behind the upper part of the head and from the ventral fins, while the eyes are still more degenerate than in the Mangoe Fish.

Another type of fish common in the deep sea is that of the genus Macrurus, which is related to the Cod family. In these fish the tail-region is very long and tapers gradually to a point, the almost filamentous structure thus produced being doubtless useful also as an organ of touch. In the creeks of the Sunderbans a genus of herring, Coila by name, is common in which the tail-region has a similar shape. On examination, however, it will be observed that while in the Macruri fin-rays are present on both edges of the tail, in the Coilae these rays are confined to the tip and the lower edge and the tail-fin is thus of a different type. In the two genera, therefore, the similarity has again come about in a different manner. Coila is an essentially estuarine, Macrurus an essentially abyssal genus.

Similar lines of evolution are also illustrated by a prawn common in the Gangetic creeks and by a genus that only occurs in the deep sea. In both these prawns the three hinder pairs of legs, which in allies of both are used mainly for walking on the bottom, are so long and slender that it is doubtful whether they can be used as organs of progression. They are certainly not so used in the estuarine form, but are trailed behind the animal very much in the same way as are the filaments of the Mangoe Fish. Here again the results of evolution are similar, both between a fish and a prawn which live in the same environment, and also between this prawn and another which lives in an environment in most respects very different. Here again, however, the resemblance is brought about in a different way, for whereas it is the terminal segments of the legs which are most produced in the estuarine prawn, it is the segments above them which are the longest in the deep-sea genus. The name of the estuarine prawn is *Leander tenuipes*, that of the deep-sea genus Nematocarcinus.

It should be pointed out that the filamentous legs of *L. tenuipes* like the "feelers" of *P. paradiseus* are a specific, not a generic character; but *L. tenuipes* is linked to the normal members of its genus by a species (*L. annandalei*) from the lowest reaches of the Yangtse-Kiang, where the water is also muddy.

This brings me to another interesting point in the estuarine fauna of the Ganges, viz. the evidence we possess that some of its peculiar forms can hardly have gained their peculiarities in the deltaic creeks. *Leander tenuipes*, for example, does not live permanently in these creeks but only ascends into them from the sea at the breeding-season. Moreover, the fauna includes at least one species which is actually related to deep-sea forms. This is the fish called, by a corruption of the native name, the Bombay Duck (*Harpodon nehereus*). It belongs to a genus otherwise known only from the deep sea and so closely resembles many deep-sea fishes in its superficial characters that the late Dr. Günther, one of the greatest ichthyologists of recent times, regarded it itself as a deep-sea fish which occasionally made its way into shallow water; but as a matter of fact it has never been captured except in shallow water and is particularly common in estuaries.

These facts, however, do not in any way provide evidence against the facts of convergence. They merely prove the multiple origin of a convergent fauna and push the origin of the convergence a step back in certain forms.

Common factors in the deep sea and the Gangetic creeks.

It is difficult to imagine two types of environment more different in most respects than the abysses of the ocean and the Gangetic creeks, but there are two important factors in common, namely, low visibility in the water and a very soft, oozy bottom. The greater part of the depths of the sea is covered with very soft ooze which in many of its physical properties is not unlike the detrital mud brought down by the Ganges. At great depths, moreover, light is completely absorbed by the overlying layers of water, and the only gleams are those produced by phosphorescent organisms. In the Gangetic creeks this of course does not happen, but the very fine silt held in suspension in the water produces a kind of aquatic fog, which makes visual organs of little use to its inhabitants. As the peculiarities of both the estuarine and the deep-sea animals appear to be definitely correlated with these two factors, it is difficult to escape the conclusion that low visibility and a very soft bottom have been, directly or indirectly, controlling influences in the parallel evolution which has occurred in so many members of the two faunas. I have cited only a few striking examples of the results of this evolution and have not discussed these in detail, but by themselves and on the facts I have stated they are too numerous and too detailed to be due to mere coincidence.

The fauna of Oriental hill-streams.

We must now turn away from the sea-coast and consider a remarkable complex of evolution that has occurred in the fauna of small streams in the Himalayas and elsewhere. I have been interested in this fauna for the last twenty-five years and knew it first in the hills of the Malaya. Since then I have observed it at home in the Darjiling district, in the Nilgiris and the Western Ghats, in Manipur, in the Southern Shan States, in Tenasserim and at Hongkong, for the same fauna ranges, with but small changes, from Nepal to Eastern China in one direction and down the Malay Peninsula into Borneo in the other. As we shall see, it has its analogues in the mountains of South India, in the oceanic Andaman Islands, in South Africa and even in South America. Certain aspects of this fauna have recently been studied by Dr. Sunder Lal Hora of the Zoological Survey of India, to whom I am indebted for many interesting facts.

The whole question of convergent evolution in this fauna is so complicated that it is difficult to discuss it without becoming diffuse and losing the argument in a tangle of details. The animals of the small mountain torrents of the Eastern Himalayas and the other ranges which extend across the mainland of South-Eastern Asia and down into the Sunda Islands are not only closely related to one another but also exhibit in their different groups a remarkable resemblance in general form. The most conspicuous and usually the most abundant groups that haunt the more rapid parts of the streamlets are the fish, the tadpoles and the insect-larvae. The members of all these groups are with few exceptions flattened from above downwards, with the lower surface quite flat; their heads are broad in comparison with their length and often more or less spatulate, as a rule rather lower in front than behind; while their backs, if not quite flat, rise in a gentle slope from in front backwards. The outline of their profile is thus admirably adapted to afford little resistance to a rapid flow of water, so long as they remain with their heads pointing upstream—the habitual attitude of most if not all of them when at rest. But the resemblances of these diverse groups are not merely of a general kind, but are close in particular organs, in the methods by which they respire and feed and particularly in the structures by means of which they cling to rocks and stones in a strong current. I will concentrate my attention on these last, for there will not be time to consider all the particulars of the convergence that has come about in this environment.

Two mechanical principles are involved in the adhesive apparatus of the fauna of mountain torrents, namely the production of friction and the creation of a vacuum. The latter is effected by means of suckers. A sucker, in the sense the word is here used, consists essentially of a pad or disk which can be laid flat on a plane surface. In order that a vacuum may be produced in it the edge of the sucker must remain in close contact with the surface to which it is applied, while its central part must be capable of being raised without disturbing its margin. In the cavity thus brought into existence a complete vacuum is created if the apparatus be perfect, because neither air nor water nor any other substance can penetrate into the cavity. A flat body with a sucker of sufficient size on its lower surface adheres tightly to any object to which the sucker is applied, when the centre of the sucker is raised; because the pressure of the atmosphere and under water of the water also is now exerted on the upper surface only of the body and is no longer exerted upon it from all directions.

The principle of the sucker is applied most perfectly in the structure of a remarkable genus of fish of the carp family which is abundant in the hill streams of India and other countries of Asia and Africa and in a group of tadpoles found in the mountain ranges of North Eastern India, Burma, Siam, Southern China and Malaysia. The fish were until recently known by the descriptive name Discognathus but purists in nomenclature now apply to them the older name Garra, which has the advantage of being shorter and also of being the indigenous name in certain parts of India. The tadpoles are those of the so-called Ranae Formosae, a group of frogs which happen to have large adhesive pads on their toes.

In both fish and tadpoles there is a large, flat disk on the lower surface just behind the mouth, which is completely ventral in position. The general structure of this disk is remarkably similar in the two animals and there are even resemblances in histological detail, although the minute structure is much more complicated in the fish than in the tadpoles. In both there is a circular or elliptical central region, which is soft and flexible in the tadpoles but almost cartilaginous in the fish; in both there is a free margin studded with minute tubercles; in both, the central region can be raised by special muscles or ligaments, which are attached in the tadpole to the vertebral column and in the fish to the free hyoid bone. In both animals certain parts of the apparatus bear microscopic spines, consisting of single cells with a horny covering. These doubtless aid in effecting adhesion on first contact, but in both animals a complete sucker is formed, for the free margin of the disk adheres fast to rocks and stones when the centre part is raised by the muscles or by the movements of the hyoid. The sucker works so perfectly that the animals can cling to stones by it in the strongest current. Dr. Hora found it possible to lift from the water a stone nearly 6 ozs. in weight by pulling at the tail of a tadpole of this kind adhering to it. The tadpole was only 2½ inches long and its weight was about one-sixtieth part of the weight of the stone. Close as is the resemblance in this peculiar structure between Garra and the tadpoles, it is inconceivable that it has not been produced independently in them, for it cannot have been present in the immediate ancestors of either.

The genus Garra, indeed, affords direct evidence of this, for the sucker is much more perfectly developed in some of its species than in others and, generally speaking, the perfection of the organ is in direct correlation with the rapidity of the current in which the species habitually lives. In sluggish streams in Baluchistan and Seistan a species (*G. adiscus*) is found in which the disk consists merely of a slightly thickened pad without a free margin. In the same streams another form (*G. rossicus*) occurs in which the margin is only partly free, while the sucker in its highest development is found only in those species which frequent the mountain torrents of Southern Asia and Tropical Africa. Moreover, in these highly specialized forms exactly the same changes have been observed in the post-larval development of the young fish. Even at a stage at which larval development is well past the disk consists merely of a thickened pad, and it is only when the fish has reached a fairly large size that a perfect sucker is formed.

In a recent visit to the Andamans I was surprised to notice in the rapids of a small jungle stream numerous little fish which closely resembled Garra in form, movements and behaviour. On capture these fish proved not to belong to the carp family, which has apparently never reached the Andamans except when introduced artificially, but to be gobies and thus to represent a different order from Garra. The disk with which they were adhering to the rocks, further, was not a special structure but produced by a slight modification of the ventral fins, which were completely fused together. These fish belong to the genus Sicydium, which is found in streams near the sea in many islands both in the Indian Ocean and in the Atlantic. Marine fish, belonging to both the gobies and other families are known in which the ventral fins are similarly and even more highly modified, and probably Sicydium has merely perfected a modification originally induced in quite other circumstances and originally used among the breakers of the sea-shore.

These facts do not exhaust the list of methods by which a sucker is produced on the lower surface of fish and tadpoles inhabiting hill streams. In many of the Ranid tadpoles of the Eastern Himalayas which have no special sucker the lips are greatly enlarged and are used for clinging to rocks. They form together a well-defined disk with a shallow, funnel-shaped centre from which the water is probably extracted by suction. The larva of Blanford's frog (*Rana blanfordii*) may be taken as an example and we may note in passing that this species belongs to the same genus as the Ranae Formosae. The same speciality is carried much further in the tadpole of the Rough Toad (*Bufo asper*), which is common in the hills of the Malay Peninsula and is said to occur in Sikkim. In the Ranid species the two lips are almost equally well developed, and also in a peculiar tadpole found in the streams of the Western Ghats but not yet associated with its adult.

This tadpole, however, so closely resembles in general structure the larva of the African genus Helophryne, at least some species of which haunt small streams and have similarly modified mouths, that I believe it to belong to the same family, the Cystignathidae, though no species of this family is known at present from the Oriental Region. In the toad it is chiefly the hind lip that is enlarged.

The frictional apparatus by means of which some fish of the mountain torrents of Southern Asia, and also some of those of similar streams in South America, cling to stones in a rapid current has not been so fully studied as that which produces a vacuum in other species. Until quite recently, indeed, the former in its highest development has been confused with the latter, but Dr. Hora has shown that both the anatomical structure and the mechanical principles are different. In its simplest form the frictional apparatus consists of little pads provided with minute retroverted spines and situated on the rays of the greatly expanded lateral fins. But it is its most elaborated form with which we are concerned here: I cannot even discuss the intermediate stages which occur in different species and genera.

The False Remora (Pseudecheneis) is a little cat-fish common in the hill streams of Assam. It has the flattened form, the expanded, fan-like paired fins and other peculiarities of other fish of the same association, but it also has a very peculiar organ on its chest. This organ consists of a series of stout transverse ridges arranged parallel to one another on a slightly raised area of oval outline. Like the disk of Garra it is produced by a modification of the integument of the chest and is provided with minute spines closely resembling those on that organ. This is of course another instance of the result of convergent evolution, for the two fish belong to different families and different suborders.

The adhesive organ of the False Remora provides, however, another and still more interesting illustration of the same phenomenon, for it closely resembles, and has the same function as that found on the head of the true Remora (Echeneis), a marine fish which attaches itself to sharks, whales, etc., in the open sea. In the Remora the organ has not only a different position but also an entirely different origin, for it is situated on the upper surface of the head instead of the chest and has been produced not by a modification of the skin only but by one of the dorsal fins. In minute structure and in mechanics these two organs, possessed by different fish not closely related to one another, are, nevertheless, closely similar, and the two species live in types of environment in most respects dissimilar, but with this feature in common, that it is advantageous to the fish to attach itself tightly to other objects in conditions which render it very liable to be dislodged.

I must not keep you longer over the animals of the hill-streams, about which much still remains unsaid. There are in particular many interesting facts about the insects as well as the fish which I must pass over. I trust, however, that I have said enough to illustrate the peculiar and diverse ways in which convergent evolution has been at work in this fauna. I have shown that there is not merely a general similarity of form between the members of the different groups of which it is composed, but also that there is a similarity both in the modifications of the same pre-existing organs in unrelated forms and even in the production of entirely new organs. In all these instances, as in others I have cited in this Address, there are certain features in common. In all, animals of different origin have come to resemble one another in special features; in all, these features are correlated either with a special environment or with a special mode of life; in all, not merely a single species or a single genus is involved, but either large families or else whole faunas or associations. In none, has anything like specific or even generic identity been produced.

The accidental transport of Typhlops.

I may state here that I cannot accept Dr. Gadow's supposed independent evolution of the blind-snake *Typhlops braminus* in Mexico and in the Oriental Region, for this little animal is peculiarly liable to be transported from place to place by human agency. It usually lives underground but also frequents the corners of houses. I have found it more than once in boxes containing clothes and once in a hollow walking-stick.

Divergent evolution.

Before discussing the theoretical bearings of all these facts about convergence I must now turn to the other side of the picture and cite a few examples of the results of divergent evolution. This phenomenon has received much less attention than its opposite, for we naturally expect differences rather than resemblances in nature. No detailed uniformity exists in evolution, and nothing is to be gained by assuming a simplicity which we know, if we think the matter out, to be non-existant.

The beetles of Madeira.

A good instance of divergence is noted by the late Dr. Fowler in his introduction to the Coleoptera in the "Fauna of British India," namely that of the beetles of Madeira. As Darwin had already observed on the evidence provided by Wollaston, a very large proportion of these beetles are wingless, apparently in correlation with the fact that insects with wings are very liable to be blown out to sea from an island and so perish. In the present connection, however, the interesting point is that one genus (Pristonychus), though most of its species in other countries are practically wingless, has ample wings in Madeira.

It is clear that exceptional powers of flight may be as advantageous on an island as a complete loss of wings.

Most of the instances I can give you from my own experience are of a simpler kind. The first is that of sponges living in muddy water.

Sponges, as most of you probably know, are animals of very simple structure, depending for food and oxygen on the currents of water that pass through the channels with which their substance is permeated. These channels are liable to be blocked up and rendered ineffective by solid particles held in suspension in the water which enters them. Consequently very few kinds of sponges can live in muddy water. I have, however, observed sponges living in this situation myself in four different localities, in the Lake of Tiberias, in the creeks of the Gangetic delta, in the Chilka Lake on the coast of Orissa and in a little creek opening into the Straits of Malacca on the coast of Perak.

Sponges in muddy water.

In the Gangetic delta only one species is able to survive. This is *Spongilla alba*, a very close ally of the cosmopolitan *S. lacustris*, from which it differs in the absence of symbiotic green algae from its cells. This sponge has no obvious anatomical peculiarities. It protects its channels from being blocked up by absorbing the little particles of silt into the ordinary cells of its flesh and then eliminating them gradually. Possibly the absence of green algae, which implies some physiological peculiarity, may be correlated with this power.

In the Chilka Lake we know of seven species of sponge. One of these is *S. alba*, another *S. nana*, a closely allied form of very similar structure. Four species, belonging to two different families, grow only in protected situations in which the mud cannot effect them, but one, belonging to a different grade from all others, remains with its base buried in the bottom and the greater part of its structure fully exposed. This last sponge, by name *Tetilla dactyloidea* var. *lingua*, is only a form of a species common in much less muddy water in the open sea. Its varietal peculiarities are two: (1) the spicules which anchor it to the bottom are much less well developed, and (2) the single aperture from which the currents of water finally pass out of it and the channels connected with this aperture can be much more tightly closed, while the pores through which the water enters into the sponge are very minute and inconspicuous.

So far, the illustration of divergence afforded by the Chilka sponges is of the most general nature, but it becomes actually specific if we compare the Tetilla with a very closely allied form (*T. limicola*) found only in Lake Tamblegam, a lagoon on the coast of Ceylon in which the conditions of life are very similar to those in the Chilka Lake. *T. limicola*, the general structure of which is very close indeed to that of *T. dactyloidea*, protects itself against mud in precisely the opposite way to that adopted by the form *lingua*, for the fairly numerous cavities through which the water finally leaves the sponge are large and flask-shaped, and thus convenient for the expulsion of particles of silt taken into its channels.

Similar instances occur in the sponges of the Malayan creek and of the Sea of Galilee, and further examples might be found in those of the lakes of Celebes and Japan. It will be sufficient if I discuss here what happens in the Palestinian lake.

In the Lake of Tiberias, the waters of which are turbid, I found five species of sponge, all belonging to the family Spongillidae and to closely related genera. Four of these sponges lived fixed to the lower side of stones (that is to say, in a situation in which they were protected from the fall of silt) and their orifices were small. The fifth, however (*Cortispongilla barroisi*), was found attached to the upper surface of small stones and shells in the channel of the Jordan where it passed through the lake. In this position the sponge was particularly liable to be buried in coarse silt. Its structure is remarkable in two respects, firstly that the outer layers of its skeleton are peculiarly dense and consequently that solid particles must be to a large extent (not entirely as was obvious from examination) prevented from entering into its substance, and secondly that one or several very large apertures are present on its surface through which the water was finally ejected in the living sponge. Each aperture, moreover, is connected in the interior of the sponge with a large flask-shaped cloaca not unlike that of *Tetilla limicola*.

Here we have both convergence and divergence exemplified in the same species, which differs from allied forms living in the same lake in the way in which it protects itself from a common danger, but agrees in this respect with another sponge quite unrelated to it and living many thousands of miles away but subjected to the same danger.

Divergent evolution is apparently not so common a phenomenon as convergent evolution, but it is less easy to detect in its results. Many further instances might, indeed, be cited, but I will content myself with two, one drawn from the vertebrates (in which it seems to be peculiarly rare), the other psychological rather than anatomical.

For my instance among the vertebrates I return to the fauna of the hill-streams about which I have already said so much.

The tadpoles of Megalophrys.

The family of toads Pelobatidae is represented in South-eastern Asia by the single genus Megalophrys. The adults of this genus exhibit considerable individual variation in anatomy as well as marked specific differences, but it is not possible to subdivide the genus on any adult character. The tadpoles, however, exhibit an extraordinary divergence. All those as yet discovered in the Himalayas are very highly specialized. They lack the horny teeth found on the lips of most tadpoles, their tails are long, slender and highly muscular.

and they have a curious structure like an inverted umbrella surrounding their mouths. This structure does not act primarily as a sucker, but among other functions has that of a float. From the hill-streams of Burma and Malaysia two distinct types of Megalophrys larva are known, not in the same species but often in closely allied species. One type is identical with that of the Himalayan forms, while the other differs little from that of the western genus Pelobates. This tadpole is remarkable for its large size, heavy build and flabby consistency. Its lips form a large flat disk furnished with many rows of horny teeth and used as a sucker in clinging to stones.

Generally speaking, the two types of tadpoles have a rather different habitat, those of slender shape and with an umbrella-like mouth inhabiting rapid-running streamlets, the others rather slower waters; but this is not always so. In hill-streams in Tenasserim I have found the two types together, that is to say, within a few feet of one another, those of the heavily built type skulking under stones, those of the other type in corners of the little pools.

In this instance we have in a single genus forms which follow the line of evolution adopted by their family as a whole, and also forms which have followed a highly peculiar line of their own; and yet the two types can exist in the same environment.

My psychological instance of divergence is again drawn from the termites.

The mounds built by Odontotermes.

On the little island of Barkuda in the Chilka Lake there is only one species of termite that builds mounds, namely *Odontotermes obesus*; but two different kinds of mounds are constructed. The inhabitants of these different mounds have been subjected to very careful examination by Professor Silvestri, one of our leading authorities on the termites. The only apparent difference that he can find between them is that the eyes of the adult female are larger in one kind of mound than in the other. He can observe no difference at all in the blind progeny of these two kinds of female, and it is of course the blind workers which build the mounds. He has, however, called the termites which have the large-eyed female var. *oculatus*.

The mounds built by the typical *O. obesus* are conical and therefore circular in cross-section. Their walls are thick and they contain numerous small chambers of more or less spherical shape in which a fungus is cultivated. The mound constructed by the var. *oculatus*, however, differs both externally and internally. In cross-section it is star-shaped owing to the fact that a number of vertical buttresses project from the central mass, which is small and for the greater part of its height almost solid, while the buttresses are hollow and empty.

At the base of the mound there is a single very large garden-chamber shaped something like a limestone cave with stalagmites and stalactites. Thus there are in one type of mound numerous small gardens, in the other a single large garden, and we may compare the difference to that between districts in which cultivation is carried on in small plots and that on which it is spread over large estates.

I have examined the males and females from a large number of mounds of both types and find that the difference in the size of the eyes is constant in both sexes. The mounds are built in exactly the same environment, with precisely the same exposure and indifferently either on sandy or on stiff red soil. The same species of fungus is cultivated in both. Here we have, therefore, a difference in instinct between two varieties of a single species in which the varietal differences in anatomy are distinguishable only in certain individuals and not distinguishable in those individuals in which the difference in instinct is manifested.

Diversity of evolution.

With this instance of divergence in instinct between very closely related animals I must bring my series of illustrations to a close. I have already stated my main object in selecting them—to demonstrate the complexity of the results of convergent evolution and to prove the occurrence of its opposite. Evolution is the primary fact in all modern biological study, but we are still as far as ever from discovering its first cause. The research of the last two centuries has elucidated in some small degree the ways in which evolution works. These ways are diverse and often obscure. The subject of my Address has not been evolution as a whole but certain ways or modes of evolution. In more than one paper recently published or shortly to be issued I have used some such phrase as this: "No one formula can express, much less explain evolution." I feel confident that in this opinion I would have had the support of Charles Darwin, who remains, despite all attempts to dethrone him, our supreme master and exemplar. Even Darwin, however, became so convinced of the truth of his explanations that in his later years he began to refine upon them and to deny the validity of theories which at first he had not definitely excluded from his own.

Importance of environment.

It was Alfred Russel Wallace who first drew attention to convergence, which he called parallel evolution. Darwin first used the term convergence and discussed many instances. In most of those I have selected myself environment plays a very prominent part. Two facts seem to be evident. Peculiar types of environment such as those which exist in the hill-streams of the Oriental Region and those we find in the

Gangetic creeks seem to be exceptionally favourable for the occurrence of this kind of evolution and it is noteworthy that such types of environment are always in a sense abnormal, that is to say, include factors or elements which are not present on most parts of the earth's surface or in most spots in its waters. The second fact is that, although peculiarities in the results of convergent evolution are often highly beneficial to the animals which possess them, yet this is not always the case.

I can recall few references in literature to divergent evolution, which, indeed, hardly seems to have been recognized as a general principle; but the two principles are complementary and it is difficult to grasp one without the other.

Mendelism.

That all instances of these two lines along which evolution has sometimes taken place are not directly due to a common cause is, I think, evident, but there are certain ways in which it does not seem to me possible that they can have come about. The clearest of these to my mind is that of Mendelian inheritance, but possibly I "underrate the ingenuity of the Mendelians." That characters are segregated in certain species and inherited along Mendelian lines in these species has been proved by experiment, but I do not think that the existence of a universal law has been proved. Most of the species selected for experiment have been domesticated animals or plants. Organisms in which characters can be segregated are particularly suitable for domestication, the progress of which throughout the centuries has been due to a conscious or subconscious selection by man of races in which it was possible by selecting the parents to ensure the production of offspring which would have some definite character or characters desirable to him. Whether these characters were of direct utility or merely subserved man's inherent craving for variety and novelty does not affect the question. Undomesticated animals such as snails and grasshoppers which have been proved by experiment to reproduce their kind on Mendelian lines are, in my opinion, merely those which would be suitable for domestication if their domestication were desirable, but there is no need to domesticate snails or grasshoppers.

Gradual changes in evolution.

There is no evidence in any of the instances I have cited, except possibly among the ants and termites, of any segregation of characters. In neither the fish of the genus Garra nor the snails of the genus Taia, in both of which we have much information as to the course of evolution both in the later development of the individual and also in the gradual changes observed in different species, does the evidence lean in this direction. In both series the full perfection of modification

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has quite clearly come about gradually, without sudden mutation and equally without the grouping of any definite characters.

In *Taia naticoides*, the most widely distributed species of its genus and the one from which all the other living forms are probably derived, individual variation is so great and the change from smooth to sculptured shells so gradual that doubt has been cast on the validity of the different species which I have recognized. Similarly in the genus Garra Dr. Hora and I are not in full agreement as to the identity of some of the more highly specialized forms, while Day grouped most of the many Indian species recognized by both Dr. Hora and myself under three specific names. In both genera the change from one species or form to another is so gradual that taxonomic certainty is perhaps impossible, and it is noteworthy that definite changes are most imperceptible in those organs or structures which have become most highly specialized in the ultimate history of the genus. And yet it does not seem possible that the modifications are due to the effect of environment on the individual. In Taia at any rate specific characters can be detected in the embryonic shells of the most stable, which are also the most highly specialized forms, particularly in *T. intha*, which we may call the culmination of the series.

By-products of evolution.

The instance of the fish, however, differs in a very important respect from that of the snails, for the modifications of Garra are useful to it, while those of Taia are mere "by-products of evolution."

Lamarckism.

The most facile explanation of the independent production of special organs of a similar nature and with a similar function such as the sucker of Garra and of the tadpoles of the Ranae Formosae or the filamentous appendages of *Polynemus paradiseus* and Bathypterois, *Leander tenuipes* and Nematocarcinus, is that of Lamarck; but these instances do not stand alone. If such organs had been produced by effort on the part of the animals to adapt themselves to their environment we might expect to find that all the modifications correlated with environment were useful to the organisms which had evolved them. But this is not the case. The modification of the shell in Tulotoma, Taia, Margarya and certain species of Neritina weakens it rather than strengthens it, for the sculpture is not produced primarily by any excess of hard matter: the shell of *T. intha*, is, indeed, exceptionally light and thin. We cannot postulate any aesthetic perception in a Gastropod, for vision is imperfect in all snails, while the most careful observation of Taia in its natural haunts has failed to reveal any enemy or natural force against which its fantastic shell could protect it.

Even, therefore, if we are prepared to concede that certain instances of both convergent and divergent evolution may be partially explained on some Lamarckian hypothesis, we cannot accept this hypothesis as of universal application any more than that of Mendel.

The importance of abnormalistics in environment.

The fact that in most situations in which convergent evolution has occurred on a comprehensive scale the environment is abnormal has, I think, special importance. It may mean either that circumstances are exceptionally favourable or that they are exceptionally unfavourable. If they are favourable to some kinds of organisms, however, they are inevitably unfavourable to others. No two organisms have precisely the same physiological reactions and no type of environment exists which is equally favourable to all. Physical conditions such as those in the hill-streams of the Himalayas or in the Gangetic creeks and the deep sea are, however, unfavourable to all animals of a generalized structure. In the hill-streams the bulk of water is small and the danger of being washed away by sudden floods is always imminent. In the Gangetic creeks and the deep sea low visibility, the danger of being smothered in mud and the abnormal density of the water are all common factors. There is no room for large animals or even for animals of moderate size in the streamlets; in small and rapid mountain torrents fish with normal buoyancy or with a sharp or rounded keel would soon be washed away. In the creeks or the deep sea an active animal which depended for the capture of its prey or for escape from its enemies on normal eyesight would be at a disadvantage, while a sedentary animal without special adaptations in structure or physiology would be overwhelmed in the silt or ooze. An animal which could not adapt its respiratory and other functions to peculiar conditions of pressure and of chemical composition of water would languish and die in both situations. Only animals specially modified through evolution can thus survive and perpetuate their race, and the range of useful modifications possible is small in such conditions.

The natural tendency towards eccentricity and its restraint.

In lakes, on the other hand, such as those I have mentioned in connection with the molluscs, the main initial difficulty for most organisms is probably the peculiar chemical composition of the water, which by limiting the number of species which can survive in it has given others a free field. Apart from this one factor conditions are favourable for molluscs. There is in all living nature a tendency not merely to vary but towards the perpetuation and growth of sheer eccentricity—a tendency of which man has taken advantage in the production by selective breeding of such *lusus naturae* as lap-dogs, fantail pigeons and three tailed, goggle-eyed goldfish. In normal types of environment eccentricity is kept within bounds and rendered useful by the struggle for existence, but it has free play—at any rate for a period—in an environment which is fundamentally unfavourable to most animals but exceptionally favourable to a few and at the same time offers equable and stable conditions guarded both from the irruption of new enemies and from inter-breeding by geographical isolation Any change in the conditions, however, is fatal to organisms in which eccentricity has reached extravagant heights. They perish inevitably, as the Dinosaurs perished, as the water-snail Bullinus perished in India as soon as the eruptions of the trap limited the marshes in which it had gained a gigantic size, as Tulotoma perished in Europe when the great lake-basins of Slavonia and the neighbouring countries were filled up. Taia and Margarya survive because their time has not yet come.

The impossibility of a simple explanation of evolution.

The more deeply we study the instances I have cited, and others like them which might be cited, the more complex does the whole question of evolution become. A simple explanation becomes more and more impossible and environment with its unlimited gradations assumes an ever-greater importance. Indeed it seems hardly too much to say that evolution is ultimately no more than the adaptation of organisms to environment.

I have gone against the precedent set by most of my predecessors in this chair in that I have attempted to discuss a definite scientific problem rather than to talk of things in general. I am told, however, that I should not let the occasion pass without improving it. Permit me, therefore, to give a few words of advice to my biological colleagues of a younger generation. I would commend to their notice the vast opportunities open to them in the study of zoology or botany from a biological point of view. I do not believe that problems such as those I have put before you this evening can ever be solved in the laboratory or the garden-plot, or that mathematics alone can provide an answer to questions in which that mysterious thing called life is concerned. Nature as we find her in the jungles and the waters of India is a very different being from the placid goddess of our British woods and lakes and rivers, and yet there are some who think that biological studies in this country should be modelled exactly on those possible in an English University.

I notice an unfortunate tendency among young Indians who have been for post-graduate study to England to adopt the guise of sedulous imitators—I am told I must not use the classical English phrase—to despise and ignore the work done in their own country and to claim that biological research is possible only in the conditions under which it is carried out in a few centres of learning in Europe or America. I no longer hear as frequently as I used to do the complaint that original work is impossible in Indian colleges because of the lack of a scientific atmosphere. but I still hear of young and active professors who have no time for research. When a man says that he has no time for anything that needs special application. I always suspect that he means he has no energy. It is the busiest men who have the most time both to do their own work and to help others.

I would like to see in India a real indigenous school of zoology, which made full use of our special opportunities. which displayed, without extravagance and with the most meticulous attention to accuracy and detail, a true originality, a power to break loose from tradition and from the scientific fashions of the moment without merely being content to say or to hear some new thing. Diligence, patience, application, restrained imagination, self-sacrifice are necessary, not merely bright ideas which can be jotted down, hastily published to retain priority—and then forgotten. The greatest opportunities for a school of the kind seem to me to lie in this country in the direction of what is called, sometimes contemptuously, scientific natural history. Morphology can be studied on preserved material just as well in Europe as in India and genetics in the limited sense of the word in any backyard. We are apt to despise natural history because it is "popular"; we ignore it because it is difficult and needs a more detached outlook, a more comprehensive understanding than the more mechanical branches of biology.

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Section of Agriculture.

President :—B. C. BURT, Esq., M.B.E., B.Sc.

Presidential Address.

FUTURE DEVELOPMENT OF COTTON-GROWING IN INDIA.

It is my privilege today to welcome the members of the Agricultural Section of the Science Congress and to say how greatly I appreciate the honour of being allowed to preside over this section. I trust that our meeting this year will maintain the high standard attained in previous years

It has been a custom amongst my distinguished predecessors to select for the Presidential Address some general question connected with agricultural development. I propose today to depart from that precedent and to invite you to consider agricultural research in its relation to a particular crop, viz. cotton. My reasons for this are three :—

In the first place, much of my time in recent years has been devoted almost entirely to this crop. Secondly, in the Central Cotton Committee India now possesses a unique organisation for the furtherance of the improvement of the cotton-growing industry ; an organisation moreover which not only is representative in character but which possesses funds of its own and is thus able to provide the means for giving effect to many of its own recommendations. Thirdly, bearing in mind that agriculture is in the first place a business and in the second place an art, it occurs to me that it may be of no small profit to ignore momentarily the conventional divisions of science and to examine briefly the problems presented in attempting the improvement of a single crop. To agricultural improvement every pure science has contributed and will contribute in future. A science of agriculture can hardly be said to have arisen as yet, but the supreme importance of the scientific method in agricultural work is now realised. If the problems requiring solution lie on the borders of several pure sciences they are the more fascinating for that very reason. and as in other branches of applied science the thorough investigation of the economic side of our problem must be provided for.

The cotton-growing industry in India occupies a position which in many respects is unique. It is true that the area under cotton is much smaller than that under food crops. nevertheless India is the second cotton-growing country in the world. Further than this, approximately half of the cotton grown in India is converted into yarn and cloth in the country

Not only is India the leading cotton-spinning country in the East but she is the fifth cotton-spinning country in the world. But, though the cotton-spinning and weaving industry is the most impoitant in India, cotton is still one of our most important exports. Thus, in addition to the actual cotton-growers no small proportion of the population is concerned with cotton trade or cotton manufacture and, apart from the production of the essential food grains there is probably no other crop with which the welfare of the country is so intimately connected. As a principal constituent of clothing, especially of cheap clothing, cotton is of intense importance to the world generally, and particularly to the agricultural classes of India and the East. The world-position in regard to the production of this most important staple is at present extremely unsatisfactory. The prices of most agricultural products have now approached to pre-war values, but cotton, a raw material of outstanding importance, still stands at well over double pre-war prices. This position is liable to be intensified when the cotton mills of Europe attempt to attain pre-war production. At present, cotton mills throughout the world are working much below their full capacity, largely for the reason that high prices have limited consumption. Those high prices have been brought about chiefly by under-production of the raw material. The reduction of the American crop has been attributed to various factors. Enhanced cost of production and a rise in the cost of labour have undoubtedly been contributing causes, but the real cause has been the damage done by a single insect pest, the dreaded Mexican Boll Weevil, which despite all efforts to check its advance has now spread throughout the American cotton belt. The areas sown with cotton in America during the last two years have been well above the average and the present area resulting from the stimulus of high prices is practically a record. But the yield per acre is again most unsatisfactory and from an area of some 38 million acres, which a few years ago produced 16 million bales and even in unfavourable years has produced 13 million bales, only a crop of 10 million bales or so is now expected. At an optimistic estimate the average production of cotton in America has fallen by 2 to 3 million bales per annum, an amount equal to more than half of the total Indian crop. Despite years of patient scientific endeavour and the application of control measures on a scale which has never been attempted in any other country and at almost fabulous cost, no real solution of the difficulty has been found. Methods of poisoning, especially with Calcium Arsenate, have been developed which will reduce the loss but at considerable cost, and there seems little hope that this method of control can be universally applied. Even where it has been successful the expense has been great, amounting to anything from 1*d.* to

$2\frac{1}{2}d.$ per lb. of the cotton produced. An even more serious consideration is that under weevil conditions cotton-growing threatens to become unprofitable in a considerable portion of the American cotton belt, thus suggesting further reduction in cotton production. The conclusion is obvious, *viz.* that unless other parts of the world can increase their production of cotton, especially of cotton of certain types, the clothing supply of the world will be restricted for years to come.

Increased cotton production in India has often been urged and is undoubtedly possible, but it is desirable to recognise frankly what our limitations are India, in certain respects, is a fully developed country with a dense population and consequently with only limited opportunity for increasing the *area* under any particular crop. Direct increases in the cotton area have been possible in recent years by the extension of canal irrigation. The creation of canal colonies in the Punjab not only added 800,000 acres to the cotton area (and some 300,000 bales in yield), but has made possible the cultivation of half a million acres of long-staple cotton. The Sukkur Barrage and canal scheme in Sind will probably enable an equally important advance to be made during the next ten years, but I must not dwell on this point as it forms the subject of a paper by Mr. Main. For the time being at any rate we have probably reached the limit of direct additions to the cotton-growing area Any other additions must be at the expense of other crops. The area under cotton in India does respond directly to enhanced prices and has done so in recent years, but in many respects the cultivator is not a free agent. Not only does a dense population necessitate a large area under food crops and under fodder crops to support a large, though inefficient cattle population, but the fact that holdings are small militates against the maximum area being devoted to the so-called commercial crops.

It is unnecessary in an assembly of agriculturists to lay stress on the need for rotations. It is now widely recognised that existing rotations in India are based in most cases on sound economic and practical considerations and are not readily disturbed. It is, therefore, to higher agricultural yields that we must look for the principal solution of our problem—not only higher cotton yields, but better yields from all crops and a higher agricultural efficiency all round, thus releasing land for increased areas of revenue producing crops.

It is common knowledge that like other crops cotton is dependent largely on the vagaries of the monsoon. I should not have considered it necessary to refer to this but for the fact that the effect of the monsoon on the cotton area, as distinct from yield, is not always recognised I am indebted to Dr. Leake, Director of Agriculture, United Provinces, for some figures which clearly illustrate this point. Approximately one-third of the cotton of the United Provinces is grown on canal irrigation and he has shown that, in recent years, this area has been almost directly governed by the relation between the prices of cotton and wheat, the correlation factor being high and positive, viz. $\cdot 57 \pm \cdot 11$. For the un-irrigated cotton area the contrary is the case, the area sown being almost directly determined by the nature of the monsoon prior to the middle of July, the correlation factor between rainfall prior to 15th July and cotton area being $\cdot 62 \pm \cdot 11$. If we except the canal-irrigated tracts of Northern India a similar relation, similar to the latter, may be said to hold fairly generally. Fluctuations in area through conditions beyond the control of the grower must therefore be expected. The effect of the monsoon on yield is too well-known to need emphasising.

The problem before the Agricultural Departments therefore is not an increase in area but an increase in the profits obtainable from cotton production. Every advance in this direction tends to be reflected in the area and is directly reflected in production. It is necessary to state most clearly however that the mere increase in the quantity of cotton produced, though important in itself, is not the real objective. If India is to assist to her own profit in meeting the present world's shortage, it is essential that she should produce more of the type of cotton which the world requires. It has already been stated that India is the second cotton-producing country in the world. Her average cotton crop is approximately 5 million bales, equivalent to 4 million American (500 lbs.) bales, as compared to an American crop of some 10 million bales. But 70% of her cotton is of so short a staple that it can only be used to a limited extent. The cotton spinning and weaving industries of the world have developed mainly on the basis of the type of cotton which America has supplied in the past, i.e. cotton of not less than $\frac{7}{8}''$ staple. At leat 30% of the Indian cotton crop is of only $\frac{5}{8}''$ staple and 70% is below $\frac{7}{8}''$. India exports well over a million bales annually of these very short-staple cottons, and there is no indication that the world's spindles can use very much more of this quality. On the other hand Indian mills absorb something like half of our average commercial crop, and out of the 2 to $2\frac{1}{4}$ million bales which they use, over one million bales are of staple cotton, i.e. cotton of $\frac{7}{8}''$ and upwards. Of such cottons there is only a small margin, estimated at an average of some 250,000-300,000 bales per year. Incidentally, in certain years, the imports of American cotton into India have been as high as 100,000 bales, and there is a regular import of similar cotton from Africa.

In the past India has occasionally experienced difficulty in selling promptly the whole of her crop in a year of large production, e.g. when in 1919-20 an Indian crop of nearly 6 million bales coincided with a fair crop of American cotton, resulting in a carry-over, on August 31st, 1920, of over a million bales in Bombay alone and exclusive of mill stocks. The crop in the following year fell below 4 million bales thus relieving the situation. But it is clear that our percentage of short-staple cotton is unhealthily high. It will be obvious that our ultimate objective should be to enable the Indian cotton cultivator to produce a cotton which will be freely competed for in the world's markets every year: at present this is not the case. At the present moment while American cotton is selling at some 20*d*. per lb. Indian short-staple cotton is fetching only about nine annas per lb. I have dwelt on this question at some length because it has often been urged in the past, and from authoritative quarters, that India should produce more cotton whatever the quality may be. The truth appears to be that, even with the present world's shortage, there is only a limited demand for cotton of less than ⅞″ in staple.

As is well-known India at one time produced a larger proportion of stapled cottons than at present. Within recent history, for example, the Central Provinces and Berar grew chiefly *Bani* cotton *G. indicum*—a cotton of one inch staple and over, one of the best of our indigenous cottons—instead of the short-staple cotton which now forms the bulk of the crop. The irony of the situation lies in the fact that it is largely the development of cotton spinning with modern machinery in the East which has led to the replacement of long by short staple cottons. Indian mills and China and Japan are by far the most important outlet for short-staple cottons although the demand from the Continent is by no means unimportant.

Such cottons as *Bani* are characterised by a low ratio of fibre to seed and in most tracts by a relatively low yield per acre. Until cotton marketing in India reaches a much higher standard of perfection than we can foresee at present, only in very rare cases, if ever, could an Agricultural Department advise the substitution of a high quality cotton of low average yield for an existing variety of higher yield.

The ratio of cotton lint to seed, or the ginning percentage, as it is commonly called, is also an extremely important though not the critical factor. In most parts of India the cultivator sells unginned cotton, i.e. *kapas*, and in consequence, so far as he is concerned, ginning percentage is only one of the commercial qualities of *kapas* and therefore capable of being set off by lint quality, provided that the necessary primary market facilities can be established. The ideal cotton for any tract would be one with growing period adapted to local climatic conditions, equal or superior in yield to the present varieties equal to them in ginning percentage and with a staple of *at least* ⅞″ and preferably over 1″. Such an ideal is not impracticable, but the difficulties to be overcome in its attainment vary greatly in different tracts. The three means at our disposal to securing this end are :—

(1) The isolation of the best unit species from the existing mixed crop.

(2) The use of an acclimatised exotic often involving irrigation facilities and, for complete success, involving the isolation of pure lines.

(3) Hybridisation.

In those areas which already grow cottons of relatively long staple, the first method has already given excellent results. In the Tinnevelly tract the isolation of the Karunganni constituent from the crop has given a cotton of superior staple and better yield. The same is true of the Westerns and Northerns tracts. In South Gujerat the deterioration due to the invasion of this area by a short-staple herbaceum cotton of high ginning percentage has been checked by the isolation and establishment over practically the whole of the Surat district and a considerable portion of the Baroda State of a longer staple unit type.

In Dharwar success has been attained by the isolation of pure types from Kumpta and Dharwar-American cottons. The latter, incidentally, is an acclimatised exotic American of ancient origin.

The second method has met with conspicuous success in the Punjab and in Madras, in both cases a short-staple cotton having been replaced by a long-staple cotton. Punjab-American, which is now grown on half a million acres, is a selection from Upland American introduced originally into Bombay over fifty years ago. Cambodia cotton, now grown thoughout the Coimbatore and parts of other districts in Madras, is an American type obtained from Indo-China. In both these cases success has been possible by the development of these cottons as an irrigated crop. The success of Cambodia is of particular interest as the irrigation is from wells, and the cultivation intensive comparable with that given to garden crops.

In the Central Provinces and Berar and in the United Provinces, where the existing cottons are of very short staple, the material for selecting a type of $\frac{7}{8}''$ to $1''$ staple probably does not exist. With canal irrigation part of the United Provinces can grow an acclimatised Upland American cotton successfully, but in the greater part of the province a cotton of short vegetative period comparable with the existing, *neglectum*, type is an essential. The same appears to be true of the Central Provinces, Berar and the Khandesh Division of Bombay. In these tracts pure line selection has produced types more profitable to the grower, for the time being at any rate, than the previous mixture, but the real problem has not been solved. In such areas ultimate success will probably only be achieved by hybridisation, although it is not possible to be too emphatic on this point.

It is by no means certain that we have yet reached a limit in the improvement of cotton by the study of the unit species contained in the present mixtures. The importance of such work cannot be over rated, for it not only provides material for temporary advances in the desired direction, but is essential to a proper understanding of the material available even if the final solution can only be found by hybridisation.

There are still some gaps in our knowledge of the inheritance and characters of cotton, particularly of those determining its commercial value. The work of Leake, and later of Kottur, Patel, Hilson and others, has done much to clear up many of the points which seemed obscure. But even now we are still ignorant of some of the factors determining the agricultural yield, and as to whether there is anything in the nature of a linkage between staple length and the lint to seed ratio. Within any given agricultural variety there is undoubtedly a general tendency for long lint to be accompanied by a low proportion of lint and for short lint to be accompanied by a high ginning percentage. It is fairly clear that no complete linkage exists, but there are probably limitations on the extent to which the two can be combined. Fuller knowledge on this question is clearly of great importance.

Physiological research is also needed to elucidate the present low yield of many types of cotton, particularly in the black soil areas. No less is it needed to elucidate the causes for the loss of crop caused by bud and boll shedding. Preliminary work in Bombay and Madras has shown that the latter offers a most fruitful field of enquiry.

To multiply such instances would be tedious. The work of the Agricultural Departments has already added enormously to the profits of the cotton grower, and if the problems which await solution before a further advance can be made demand time and patience, we can go forward with the knowledge that the scientific results achieved can undoubtedly be given effect to in the general cotton cultivation of the country, through the organisation which the Departments of Agriculture have built up.

It was my privilege last year to contribute a short paper to this section dealing with the necessity for technological research on raw materials with special reference to cotton. I was able to show then that the task of the agricultural investigator concerned with cotton improvement is in some respects rendered unnecessarily difficult by the lack of knowledge as to the precise qualities in cottons which are desired by the spinner, and by lack of facilities for testing new cottons.

Textile physics is a comparatively new branch of the subject, but has already led to very valuable results in England where investigations now being carried out to elucidate the constitution and character of the cotton fibre may, eventually lead to marked and possibly revolutionary changes in spinning methods. There is a wide field for such work in India, specially if directed to the improvement of the raw material. I shall refer again to this subject later.

No less important than agricultural research and improvement is the improvement of cotton marketing, the object being to obtain for the grower the fullest possible price for the cotton he produces. The possibility of introducing certain improvements into general agricultural practice will depend largely on such market organisation. It is not sufficient that the major markets are willing to pay enhanced prices for superior staple or for clean cotton. This premium must reach the grower. For this to be the case two conditions must be fulfilled.

Firstly, many of the present gross forms of adulteration, resulting as they do in small profits to the middleman, out of all proportion to the loss caused to the producer and to the general economic loss to the country, must be stopped. Certain Indian cottons for many years have possessed an unenviable reputation on account of the mixing of different varieties much of which is deliberate and fraudulent mixing.

Secondly, the organisation of primary markets requires improvement to bring them into better touch with major markets and to give the grower a square deal. Nor can the major markets for Indian cotton be held to be entirely satisfactory. The classification adopted, based as it is on geographical distinctions and station names, rather than on intrinsic quality, does not tend to the grower getting the full value of his cotton. Again, since the whole question of agricultural finance is involved, the possibility of developing co-operative methods of marketing may well be a critical factor. It will be seen, therefore, that the question of cotton improvement covers an extremely wide range both scientifically and commercially. Until comparatively recently the Agricultural Departments were left to deal with these various phases almost unaided.

As one of the results of the touring Cotton Committee of 1917-18 the Indian Central Cotton Committee was created in 1921 and permanently incorporated with funds of its own in 1923. This Committee consists of representatives of cotton growers, cotton traders, cotton spinners, cotton ginners, of the Agricultural Departments of the cotton-growing provinces, and representatives of the larger cotton-growing Indian States. The cotton cess, on which the Committee depends for its funds at present, produces some Rupees nine lakhs per annum, the great portion of which is devoted to the furthering of research. By means of research grants to Provincial Departments of Agriculture the Committee has been able to make provision for additional research on problems of general applicability. In the Bombay Presidency grants have been given for physiological research in connection with boll and bud shedding, research on cotton wilt, investigations in the methods of dealing with spotted cotton boll worm, and for plant-breeding work on Upland cotton.

In Madras a grant has been given for special investigations on the herbaceum cottons of the Northerns tract and a further grant sanctioned for bio-chemical research on the causes of resistance and susceptibility to disease and the effect of environment on the staple.

In the Central Provinces grants have been given to enable a more thorough study of the cottons of the province and for work on cotton wilt.

In the United Provinces a grant has been given for special investigations on the pink boll worm.

In the Punjab provision has been made for a special study of Upland American cottons under canal colony conditions.

Other research schemes are under consideration.

In addition the Committee proposes to provide for a Central Agricultural Research Institute for cotton, to be situated in Central India, for both plant breeding and physiological investigations.

I have already referred to the importance of technological research, and provision for this has been made in the Central Technological Laboratory, Bombay, which will shortly be completed. It is a matter for regret that Professor Turner, of the Manchester College of Technology, who has recently been appointed Director of this research laboratory, arrives in India just too late to be with us today.

In the course of a few months we shall be able to offer agricultural investigators the fullest facilities for the testing of new cottons and a start will be made on a general technological study of Indian cottons.

On the economic side, and in its capacity as an advisory committee, the Central Cotton Committee has taken up actively the question of checking adulteration and the improvement of marketing at all stages. Certain of its recommendations for legislation have already been given effect to by Government and others are still under consideration In particular the Cotton Transport Act passed a year ago enables any Local Government to prevent the importation, into tracts growing superior cottons, of inferior cottons for purposes of mixing. This Act is already in force in the Bombay Presidency.

Time does not permit of even a casual review of the Committee's various operations. But, apart from its more formal activities, its value as a common meeting ground for all sections of the cotton industry has already proved to be of the greatest value.

It will be seen that the Central Cotton Committee is trying to do for India the work which the Empire Cotton Growing Corporation is attempting for the British Empire as a whole, but with special reference to the newer cotton-growing countries. It marks a new departure in the development of Indian industries, for it is a body composed mainly of unofficials administering funds contributed by the cotton trade and industry for the improvement of that industry. It has initiated a well-balanced and adequately financed programme of research work and, during the two years of its existence, has made very important progress towards the solution of the many problems which the improvement of cotton growing in India involves. Not only has the industry itself provided funds for its own improvement, but individual representatives of its various branches, gentlemen occupying important positions in the commercial world, have given unstintedly of their time and thought. Team work of this nature where all interested in the improvement of cotton pull together, cannot fail to be of the greatest value. The Committee has fully justified the confidence which the Government of India and the Indian Legislature reposed in it when in January last the Committee was given a definite constitution and permanently incorporated by a special Act.

In conclusion, I would venture to remind you of the stress laid by two past Presidents of this Section on two important aspects of agricultural work. In 1920 Dr. Coleman urged the necessity for accuracy in agricultural investigations and for accurate field experiments. In 1921 Mr. Milligan drew attention to the many-sided nature of the problems with which the agricultural investigator is confronted and urged the desirability of more team work directed to the solution of a particular problem or group of problems. Not only in respect of the crop which we have been discussing, but in regard to all agricultural investigations in India, there was perhaps never a time when these two maxims stood so much in need of emphasis. Now that every Agricultural Department is busily engaged in developing the successful results of earlier experimental work there is no small danger that, during a period of financial stringency, the necessity of adequate provision for further research and experiment may be overlooked or discounted. On the other hand, the next advances in agricultural improvement may only be achieved after much patient and laborious investigation, for in many instances, we have only just come to grip with the essential features of our major problems.

Superficial or inadequately conducted experiments are no more justifiable in Applied Science than in the pure sciences.

Only by patient and co-ordinated effort are lasting results likely to be achieved.

Agricultural Engineering in Western India.—*By* W. M. Schutte.

A summary of the work achieved and in progress in the Bombay Presidency. Since 1912, 4,086 acres of land have been ploughed by mechanical means for the eradication of deep-rooted grasses, and 6,590 acres of mechanical ploughing and cultivation carried out in the Kaira District. Thereby three pumping plants for irrigation purposes have been erected with a total discharge of 12,570 gallons per minute whilst 1197 bores for wells have been carried out yielding on an average 30 gallons of water per minute per bore. One hundred and fifty cultivator students have been trained in oil engine driving. Over 35,000 iron ploughs are now in use in the Presidency and annual sales have now reached about 6,000. Emphasis is laid on the necessity for thorough investigations with the object of evolving the most suitable types of ploughs and implements at prices within the reach of the average cultivator. The problem of lifting water for irrigation purposes has only been partially solved and further experiments are necessary both in respect to pumps and prime movers. Much also remains to be done in securing suitable types of tractors for special cultivating problems.

Agricultural Holdings: their disintegration and re-union into economic units.—*By* D. Bala Krishna Murti Garu.

A desire to possess land has become innate in civilised man. This sentiment is at the bottom of all ideas of holdings. A holding can be said to be an area of land a man holds or works. An economic holding is defined as the extent of land out of which the operator makes a living or which enables him to keep himself and his family in comfort, at any rate, above want. The size of such holdings varies with conditions obtaining in several countries. Illustrations are given.

In old non-industrialized countries, several causes which are at work in producing disintegration—surplus population, want of land and facilities for expansion—are enumerated.

The peculiar conditions in India are emphasised and in addition minor contributory causes for perpetuation or aggravation of the evil are stated.

Methods suggested and adopted in other countries for minimising the effects of excessive subdivision are mentioned with a view to their adaptation to local conditions.

The paper concludes with a statement that though the subject has been discussed before, an opportunity is now taken to press the question on the attention of the peoples' Ministers and the Local Legislative Councils as the "Taxation of land" has become a transferred subject and is entirely under their purview.

A Preliminary Note to the Study of Fixation of Ammonia in South Indian Soils.—*By* T. S Ramasubramanian.

The paper is a record of preliminary observations of the behaviour of ammonium sulphate towards four different types of soils obtaining in South India, namely, Paddy, Garden, Black and Estate (Planting Districts). Except the estate soil the three other soils have a high fixing capacity. The process of fixation appears to be essentially chemical, as there is a definite exchange of bases consequent on the fixation. Estate soil behaves abnormally in that, that it is holding back some of the sulphuric acid and the probable causes of such behaviour are also discussed.

Research work in Animal Nutrition in India.—*By* P. E. LANDER.

Research work in Animal Nutrition in India should proceed systematically for the determination of true values of fodders and feeding stuffs. chemical analysis being supplemented by digestion trials and biological experiments.

The production of an increased milk supply of high quality is of primary importance, both from an Economic and Health point of view.

Research on Animal Nutrition in India.—*By* A. J. WARTH, ESQ.

The field of enquiry on Animal Nutrition in India is extensive. On the one hand nothing is known of the nutritive values of our commonest foodstuffs; on the other hand we have no information regarding the requirements of our indigenous Breeds.

Initial effort, which must concern itself with both these aspects, should be devoted to the estimation of digestibility of foodstuffs and to the determination of maintenance rations. The work done along these lines by the Animal Nutrition Section at Pusa during the two years of its existence is briefly referred to.

Experiments with apatite and super-phosphate on plant growth in soils round about Vizianagram.—*By* V. ACHUTA RAO.

Apatite found in Vizianagram State has been analysed and found to contain about 40% of P_2O_5. Super-phosphate has been prepared from this mineral. Pot cultures have been carried out with this super-phosphate on pulses and cereals in alkaline, neutral and acid soils round about Vizianagram. Super-phosphate in combination with potassium and nitrogen salts has also been tried. Powdered apatite when applied in the case of some of the soils, seems to give better results. Field trials have been started.

The Economic Aspect of the Cattle-breeding question in India.—*By* W. SMITH, ESQ.

The cattle-breeding is the most universal, the most difficult and economically the most urgent problem confronting Agriculture in India.

It offers great possibilities from an economic point of view in two directions:—

(1) In the development and improvement of the work and milch cattle of the country on dual purpose lines.

(2) The elimination of the unfit and useless animals which under present conditions the country supports; in short India wants fewer cattle and better cattle.

The Improvement of the Coconut Jaggery Industry on the West Coast.—*By* B. VISWANATH and K. GOVINDA NAIR.

Experiments showing (1) that the proper cleaning of the juice collecting vessels is essential for the production of good jaggery and (2) that a good crystalline brown sugar can be easily prepared out of the sweet juice of coconut, are published as a second notice. Samples of jaggery and sugar will be shown.

Characteristics of an Early Ripening Type of Cotton. —*By* G. B. PATEL.

Characteristics of an Early Ripening Type of Cotton as studied from the characters: (1) Node on the main stem from which first primary fruiting branch starts, (2) Length of Internodes, (3) Size of the leaf, (4) Habit of the strains to develop fruiting branches from the accessory buds on the main stem, on vegetative branches and on primary fruiting branches and thus reducing vegetative growth in proportion to the formation of fruit forms, (5) Size of the Boll.

Gossypium in the cotton belt of the United States of America.—*By* K. I. Thadani.

The paper briefly reviews the American cotton situation in the United States of America. The cotton belt has been geographically divided into three sections and the types of cottons and varieties grown in each section have been described. An analysis of the American cotton crop with reference to the length of staple has been made and it is estimated that the bulk of the crop amounting to about 65% is of 1 inch staple. The cultivation of $\frac{7}{8}$" stapled cottons which amounts to about 5% of the total crop is greatly discouraged in the United States for the reason that any admixture of this cotton upsets the mills- which are set exclusively for the manufacture of longer stapled material. Further it is believed that it would not pay the American farmer to grow $\frac{7}{8}$" cotton in competition with the farmers of the East where labour is cheap and where short stapled cottons grow abundantly and the cultivation of long stapled cottons is not successful.

The principle of growing cotton on one variety basis and the importance of the use of pedigree seed by the American farmer are also mentioned.

The methods of cultivation and marketing, the boll weevil situation and the advent of the pink boll worm from Mexico and the methods of control have been briefly described. A short history of the development of Egyptian cotton growing in the hot irrigated valleys of the South West which have much in common with the Indian Provinces of the Punjab and Sind has been given. The lessons to be gained from Arizona experience and the possibilities of Sind when the Sukkur Barrage project is completed have been described.

The Future of Cotton Growing in Sind under perennial irrigation.—*By* T. F. MAIN.

The decision to proceed with the Sukkur Barrage scheme marks the greatest development in the possibilities of growing more cotton of good staple in India. The ultimate area of irrigated cotton in Sind may reach one million acres.

A summary is given of the earlier history of attempts to grow better cotton in Sind and from the results achieved in the past certain conclusions are reached as to the type of cotton most likely to prove successful and the steps necessary to establish it.

Some Aspects of Large Estate Farming in the Punjab.—*By* W. ROBERTS.

The Punjab Government when colonising the Lower Bari Doab tract allotted certain large size grants of land, varying from 2,000 to 7,000 acres, on lease for specific purposes. A total of about 60,000 acres has thus been allotted or less than $\frac{1}{4}$% of the cultivated area of the province. These large estates are held on much stricter conditions than ordinary small grants (25 to 125 acres) and have materially aided agricultural development in this canal colony. A description is given of the British Cotton Growing Association's grant at Khanewal which is specifically for the encouragement of staple cotton growing including the testing of varieties on a commercial scale, pure seed production and a buying agency.

Possibilities of producing long-stapled cotton in India.—*By* G. L. KOTTUR.

The world's shortage of raw cotton is more acute in the case of long-stapled growths. United States grows three-fourths of the World's cotton and is thus the chief source of supply. India has a considerable production but the bulk of her cotton is short-stapled and therefore of very little account. There are however great possibilities of developing the Indian crop and these developments are sure to relieve the situation of the world's cotton trade and at the same time benefit the mill-owners and growers of India

Roughly three-fourths of the Indian crop is short-stapled and one-fourth medium-stapled suitable for spinning 20 counts. The latter quality is more profitable to export but the Indian mills consume about 80% of it so that what is left for export is almost entirely short-stapled. To grow as much medium staple as possible in the short-stapled areas therefore would mean good progress in staple improvement. This can be done by breeding suitable types of medium-stapled cottons.

Indian cottons do not possess a staple longer than one inch. For producing therefore a staple over an inch in length foreign cotton may be of use. And in this connection it may be stated that there is good scope for breeding suitable long stapled cottons from American varieties. The tracts which are already growing acclimatised American cottons can be made to yield long staple by growing the first generation seed of the cross with the Sea-Island. Tree cottons which yield long staple can be profitably grown in certain favourable regions if cultivated with proper care.

The control of Cotton Pests in Northern India.—*By* P. B. RICHARDS.

It is stated that the effective control of insect pests would be equivalent to increasing the cotton area by 30 to 50 per cent. Insect pest of cotton in Northern India are numerous but the two principal offenders are the spotted boll worms of the Earias species and the Pink Boll worm, Platyedra Gossypulli, particularly the latter. The life histories of these are described. Various possible control methods are discussed and it is shown effective control, particularly of the Pink Boll worm, means a large organisation and considerable outlay. Before this can be attempted incontestable experimental evidence and proof of the efficiency of the methods proposed is required. Experimental work now in progress at Cawnpore is directed to this end.

A preliminary report on the investigation of cotton wilt in the Central Provinces and Berar.—*By* J. F. DASTUR.

The wilt disease of cotton which is responsible for considerable damage to the cotton crop in C.P. and Berar has been so far believed to be caused by a fungus, a species of Fusarium, but in the author's opinion irrefutable evidence has not been produced to support the fungal nature of the disease.

It has been found that in the diseased tissues of wilting plants there is an accumulation of salts of iron and aluminium. The presence of the accumulation of these salts is found, by microchemical tests, even in the absence of the fungus, in the case of plants in the very early stage of this disease; while the fungus has never been found in absence of these salts. The fungus mycelum, even in very badly wilted plants, has not been found to fill the lumen of the vessels, still most of the vessels have ceased to function. Inoculations with the fungus isolated from diseased plants have invariably given negative results. The internal appearance, macroscopic and microscopic, of the tissues of the plant in which one per cent solutions of salts of aluminium and iron have been injected are typically similar to that of the wilted plants and give the same microchemical reactions as the wilted plants. It has been observed that healthy plants and those attacked by *Rhizoctonia solani* Kunz do not give the microchemical reactions for these salts. Healthy plants growing in sand were transferred to solutions of aluminium chloride of varying concentrations and it was found that 0.01 per cent N. solution was toxic to the plants. It is therefore suggested that the invariable accumulation of these salts in the tissues of wilted plants may have some connection with the wilting of the plants and that the fungus found in the wilting plants follows in the wake of the accumulation of the salts and may be only a secondary factor in the death of the plants.

Some Recent Advances in the Protection of Cattle against diseases: (A) Tick-borne diseases, with some remarks on the diseases of cattle caused by protozoa.—*By* H. COOPER.

A brief account is given of the losses caused among cattle (1) by ticks *per se*, through producing loss of condition by extracting nutriment for their sustenance from cattle, (2) by transmission of specific infections, notably the so called piroplasmoses (including tropical "red-water." *Theileria mutans* infection and East Coast fever).

Methods are described of eliminating these losses, by the eradication of the ticks. Experience has shown that the best means of accomplishing eradication is by the "dipping" of cattle over wide areas in suitably constructed "swim" tanks at regular, estimated intervals in a solution of arsenite of soda of a known concentration.

The author also gives some information concerning the importance of the group of intestinal disorders caused by coccidia.

(B) The modern application of (i) *Quarantine Measures*, (ii) *Serum and Vaccine* Inoculations, for the Control of Cattle Diseases.—*By* J. T EDWARDS.

The author briefly outlines the principles underlying the application of the above methods in the control of rinderpest, haemorrhagic septicaemia, black-quarter, foot and mouth disease, anthrax, contagious abortion and tuberculosis.

The fruit moth problem in the N. Circars.—*By* P. SUSAINATHAN, F.E.S.

Frequent reports were received in 1921 and 1922 from the Kistna Dt. about the ravages of certain moths puncturing oranges, etc. In the latter year a few experiments on poison baiting the moths were conducted with partial success.

The question was earnestly taken up in 1923 and the breeding places of most of the moths discovered, and in June to July of the same year a campaign was instituted against the known fruit moth breeding weeds. This put off the main brood in that particular village and saved the crop. But due to the indifference of the owner in not having continued the destruction of the weeds, a subsequent brood developed attacking the fruits. In contrast with this another orchardist in another village obtained good results from the early removal of the weeds referred to.

An eradication in a given area of the wild plants on which the larva breeds is clearly a shorter cut to the solution of the problem of the fruit moths than seeking to destroy the moths by attracting them to poison baits. Truly " Prevention is better than cure."

The continuous growth of Java Indigo in Pusa soil. A further contribution to the theory of Phosphatic Depletion in the soils of Bihar.—*By* ALBERT HOWARD AND GABRIELLE L. C. HOWARD.

Java indigo has been continuously grown in the same soil in a lysimeter for five seasons in order to ascertain whether any falling off in yield takes place. No phosphate was added at any stage, nevertheless the yields have shown no diminution such as would be expected from the phosphate depletion theory. Two difficulties were encountered in this experiment during the rains—loss of permeability and a shortage of combined nitrogen. The cause of this loss of permeability appears to be the formation of colloids which lead to the water-logging of the pore spaces and to defective aeration. Substances like sulphur and dilute acids help to restore the fertility. It is suggested that the difficulties encountered in the growth of many of the crops in Bihar are not due to phosphatic depletion but to the water-logging of the pore spaces during the late rains following the formation of colloids. The explanation of the results obtained with green manure and super-phosphate may be due to the artificial manure acting as a weak acid on the colloids during reversion.

Some suggestions to the market gardener in checking Insect Pests.—*By* RAMAKRISHNA AYYAR T.V.

It is a well-known fact that nowadays market gardening is found to be a very paying concern, especially in view of the growing demand for fresh vegetables, fruits, etc., in the great city markets. Cultivators living in the suburbs of large cities who have been till now engaged in the time-honoured custom of growing ordinary staple food crops are taking up to market gardening. But one important impediment to their successfully carrying on the work with profit is the injury caused to their crops by insect pests of different kinds. A general knowledge of such insects and of some practical measures that might be adopted in checking their ravages cannot but help them very much in this direction. An attempt is made in this paper to give a general idea of the control measures that may be adopted by the market gardener to check pests.

An improved method of Lucerne Cultivation: II.—*By* ALBERT HOWARD.

An improved method of lucerne cultivation, suitable for the alluvial soils of Bihar is described. By this method the yield is increased and a material saving in irrigation water is obtained. The method also enables lucerne to behave as a perennial in these close soils. The introduction of this useful fodder crop into the general rural economy is discussed.

Mosaic and other related diseases of crops in the Bombay Presidency.—*By* G. S. KULKARNI.

Though the mosaic diseases of plants have been known in Europe and America from a very long time, they have been of recent recognition in India. Many of the obscure diseases of crops, such as cardamom, potato, brinjal, chillie, tobacco, and others have been traced to mosaic trouble. The importance and the existence of mosaic diseases have been proved and their further study urged.

An intensive nitrifying bed as a means of preventing nitrogen losses from Cattle urine.—*By* N. V. JOSHI.

Large losses of nitrogen occur when urine is preserved under aerobic conditions. Experiments undertaken with a view to establish an intensive nitrifying bed for the rapid conversion of urine into nitrates are described. By this process the nitrogen losses from urine occurring under aerobic conditions are prevented. Two methods are described. In one urine is passed over a nitrifying bed and ultimately recovered as a solution of nitrate. In the other urine is absorbed by means of a specially prepared soil.

In the first method, Pumice or broken brick serve as suitable substrata for the organisms in the nitrifying bed. The depth of layer of liquid to be nitrified possesses great influence over the nitrification process. Urine could not be nitrified directly without dilution in the nitrifying beds up till now. With the most active bed prepared so far urine required to be diluted with ten times the quantity of water.

In the second method, soil prepared by previously nitrifying some nitrogenous material in smaller quantities and washing out the nitrates is used for absorption of urine. If ordinary local soil is used for absorbing the urine directly without any such preparation large losses of nitrogen (approximately 70–80% of original amount) occur. The object of preparing the soil is to activate the nitrifying organisms and thus make the soil capable of nitrifying the high quantities of nitrogen in the urine rapidly and thus prevent losses of nitrogen which would otherwise occur.

Some factors affecting Nitrogen changes in Black Cotton Soil.—*By* F. J. PLYMEN *and* D. V. BAL.

(1) The effect of the rainfall during the monsoon upon the oxidised nitrogen of black cotton soil has been studied.

(2) Figures are given showing the relation between the moisture content of the soil *in situ* and the nitrifying power of the soil.

(3) A moisture content of from 24 to 30% appears to enable black cotton soil to attain its maximum biological activity as regards nitrification.

(4) This activity is of a fairly high order as under the moisture conditions above stated and at the temperature prevailing during the monsoon months 50 to 60% of added organic nitrogen is oxidised in two weeks.

(5) Under the climatic conditions described in the paper, black cotton soil only shows any considerable bacteriological activity during the months from approximately mid-June to mid-October.

(6) Laboratory experiments in which definite quantities of water were mixed with air-dry black cotton soil agree with observations made on soil taken direct from the field.

(7) Nitrification in artificially watered soils previously air-dried is slower in starting than with soils receiving a natural rainfall, but the nitrifying efficiency after a period of eight weeks is about the same.

(8) A heavy clay soil which had lost its texture showed at first a diminished nitrifying power when compared with the same soil in good condition.

The Phosphatic Nodules of Trichinopoly and their manurial value for paddy.—*By* M. R. RAMASHWAMI SIVAN.

A deposit of phosphatic nodules containing 56 to 59% of tricalcium phosphate, about 17 to 20% of calcium carbonate, 7% of iron oxide and aluminia and 7% of silica is present in the cretaceous formation of the Trichinopoly district lying on the surface and embedded in soft yellow clays; and the quantity is estimated at 8 million tons, to a depth of 200 feet, over a tract 10 miles long and 1 mile broad.

Paddy soils in the adjoining Tanjore delta, of which over a million acres are under the crop, are very deficient in total and available phosphoric acid, as revealed by the soil survey of the tract, and a suitable phosphatic manure is necessary for these soils.

The nodules are not suitable for the manufacture of superphosphate and have, therefore, to be applied directly to the soil in a finely powdered condition, and experiments have been carried on to determine the availability of the flour phosphate under swampy conditions.

Water containing carbonic acid dissolves tricalcic phosphate to an appreciable extent; and the greater the quantity of carbonic acid acting on it, the more does it dissolve. The decomposition of organic matter in the form of green manure under swampy conditions of cultivation results in the formation of sufficient carbonic acid to convert appreciable quantities of tricalcic phosphate into dicalcic and monocalcic phosphates which are soluble in soil water.

The availability of phosphate in composts made with green manure measured by its solubility in different conventional reagents, shows that the solubility is greatest in one week's compost and to decrease in longer-kept composts. The large diminution in weight of the organic matter of the long-kept composts suggests that the organic matter continued to decompose during the composting period evolving carbonic acid and sour organic acids tending to a greater solution of phosphate all the time, but that the dissolved phosphate as speedily reverts to insoluble form by the action of lime present in the compost.

Measured by the yield of paddy grown in pots, it is found that the organic matter renders the phosphate available and produces an increased crop. Increased applications of flour phosphate do not give increased cropping, both with and without green manure, unless nitrogen which is a limiting factor in the soil is also supplied. The average relative yield of dry produce calculated from the results of experiments carried on for a number of years is as follows:—

No manure	34
Phosphate only	48
Nitrogen only	72
Green manure only	100
Nitrogen + Phosphate	90
Green manure + Phosphate	128
Green manure + Nitrogen	132
Green manure + Nitrogen + Phosphate ..	167

The results show that green manure renders the phosphate available, and that, when nitrogen is also applied, the increase in crop is very evident.

As regards co-operative field experiments on ryots' lands, soils containing over ·01% of available phosphoric acid do not respond to flour phosphate, but those containing less than ·01% of available phosphoric acid give an average increased yield of grain of 11%.

Field experiments at the Manganathu Agricultural station and on standardised plots of the central farm, for 4 years, gives an increased yield of grain of 13% and 9% respectively, in favour of green manure + phosphate plots over green manure.

It is recommended (1) that the supply of phosphatic manure should be more largely obtained from the phosphatic nodules which should be crushed as fine as possible, the manure being priced as much for its degree of fineness as for its content of phosphoric acid, and (2) that the flour phosphate be ploughed in with green manure or mixed in suitable proportions with organic manures like oil cakes.

Mechanical Analysis of Soils by the Tube Sedimentation Method.—*By* M. R. RAMASWAMI SIVAN *and* M. RAJAGOPALA AYYAR.

There are several methods in vogue for carrying out the mechanical analysis of a soil, some of which require elaborate apparatus, while others may take a month to complete if the soil is a clayey one. The tube sedimentation method can be performed with very simple apparatus within one day and as many fractions obtained from the analysis as may be required.

This method, adapted from the work of a chemist in New Zealand, has been in use in the Coimbatore Agricultural College for 12 years, using a long glass tube, one end of which was attached by a wide rubber tubing to the neck of a small Erlenmeyer flask whose rim was neatly cut off and firepolished. Particles of soil were often found lodged in the rubber connection or on the shoulders of the flask, and glass tubes closed at one end—rounded or blown into a small bulb—have been used for the last two years with remarkable success. These tubes were prepared by the Allahabad Scientific Instruments Co. at a small cost.

The details of the analysis are as follows:—

The preliminary acid and ammonia treatment are not followed, but 5 grams of carefully sampled soil are boiled in a beaker with distilled water for 15 minutes and transferred without loss to the long tube which is then filled with distilled water; the open end is closed with the thumb and quickly inverted over a weighed small flat porcelain dish kept immersed in a large glass dish containing about 1 litre of distilled water. Several flat porcelain dishes, previously weighed, are kept ready, and, at intervals of 5 minutes, 15 minutes, ½ hour, 1 hour, 3 hours, 8 hours and 24 hours, the dishes are replaced under the water, one after the other, taking care that as little of the soil as possible passes into the large glass dish. The clear water in each porcelain dish is decanted, a few particles of each fraction are examined under the microscope for size, and each fraction is then dried and weighed. The fraction coming within 5 minutes is separated by sieves into 3 fractions. At the end of 24 hours, the contents of the tube are emptied into the glass dish, and treated with a solution of common salt, and the colloid clay is precipitated and estimated. Moisture is determined in the soil simultaneously. The total percentage of all the estimations always makes up to nearly 100, a result rarely obtained even in official methods.

The results obtained by the Tube Sedimentation Method have been compared with the results obtained by the Beaker Sedimentation Method from several samples of soils and are correlated and represented in charts as fine gravel, coarse sand, fine sand, silt, fine silt and clay.

Studies in the Chemistry of Sugarcane. II. Some factors that determine the ripeness of Sugarcane.—*By* B. VISWANATH *and* S. KASINATHA AYYAR.

The present communication is a continuation of the paper read before the Science Congress at Bombay in 1919.

Work done subsequent to that year or embodied herewith confirm the conclusions arrived at in the previous paper; based on those conclusions a method for the determination of the ripeness of cane is outlined.

The methods now in vogue for determining ripeness are discussed in detail. A new method, namely the ratio of $\frac{\text{Top Juice Brix}}{\text{Bot Juice Brix}}$, is formulated, and experimental evidence in support of its usefulness is adduced. It is hoped that the new method will be valuable in manurial and varietal tests.

Section of Mathematics and Physics.

President:—PROF. C. V. RAMAN, M.A., D.Sc

Presidential Address.

Owing to absence from India the President has been unable to arrange for inclusion of his Address in the Proceedings.

World Weather.—*By* G. T. WALKER.

An examination of the relationships in summer and winter of pressures or rainfalls at twenty well-distributed 'centres of action' over the earth enables us to recognise types of oscillation extending over several wide regions of which the chief type governs the variations over the southern hemisphere and part of the northern: and we are led to divide the earth's surface into positive and negative areas over the first of which pressure increases while over the second it decreases, or vice versa: but in some regions the classification does not apply throughout the year.

Many of the relationships are between the conditions of one region and those of another six months later and an examination of conditions at times intermediate between these should enable the links in the chain of cause and effect to be discovered. The prime cause is certainly not the solar activity as represented by sunspots, but seems to be some natural oscillation of the atmosphere and its earliest point of manifestation at the earth's surface that has been found is in South America, where there is a marked oscillation between the pressure and that in the Antarctic immediately to the south.

Earth-currents associated with diurnal magnetic variations.—*By* S. K. BANERJI.

Extensive series of earth-current observations have been made on telegraph lines and cables and also on lines especially constructed for the purpose; but any theoretical discussion of the facts so far collected has been difficult on account of absence of knowledge regarding the causes which produce them. It is clear however that causes, which produce terrestrial magnetic variations, must produce variations in earth-currents as well. The diurnal magnetic variations are now known to be due to the combined effects of electric currents circulating in the earth's upper atmosphere, under the impulsion of electromotive forces produced by the convective motion of the air across the earth's permanent magnetic field, and the currents induced in the conducting material of the earth (Schuster, *Phil. Trans.*, A, vol. 180, p. 467, 1889; A, vol. 208, p. 163, 1907; Chapman, *Phil. Trans.*, A, vol. 218, p. 1, 1919). Agreement with the observed amplitude ratio and phase difference between the external and the internal portions of the magnetic field could be obtained only by assuming a non-uniform conductivity for the material of the earth. As a first approximation it was supposed that only a concentric core of the earth was conducting, and, to obtain the best agreement with the observed facts, a thickness of about 250 kilometres was estimated for the non-conducting shell surrounding the core, having a conductivity of $3 \cdot 6 \ 10^{-13}$ C.G.S. units (Chapman, *Phil. Trans.*, A, vol. 218, 1919). It has also been found that the influence of any probable depth of moist earth is almost negligible, but that a comparatively shallow oceanic shell produces induction effects comparable with those of the supposed core

(Chapman, *Trans. Camb. Phil. Soc.*, vol. 22, p. 463, 1922). On account of this definite location of the causes which produce the diurnal magnetic variations, it is possible to determine the magnitude and the type of the earth-currents flowing over the earth's surface which accompany these variations. These currents have been found by Chapman to satisfactorily explain the diurnal variations of the southerly component as observed by Weinstein, but not the easterly. A further examination of the matter was therefore considered necessary and is embodied in the present paper. The discrepancy noted by Chapman was due to the failure of the magnetic potential function used in the investigation of diurnal magnetic variations to correctly represent the northerly component of the magnetic force on which the easterly component of the earth-currents largely depends. The present enquiry was rendered possible on account of a more accurate determination of the earth's magnetic potential by Dr. Bauer (*Terrestrial Magnetism*, March-June, 1923), and by Sir Frank Dyson and Mr. H. Furner (*Monthly Notices of R.A.S.*, Geophysical Supplement, May, 1923), which represents more correctly the northerly, easterly and the vertical components of the observed magnetic force and further suggests the possible existence of vertical currents. The question of depths to which this type of earth-currents penetrate has also been considered in the paper and the results discussed with the observations made by Lammont and others.

Statistical Studies.—*By* P. C. MAHALANOBIS.

Various correlations between certain meteorological and other elements.

A study of Atmospheric Potential Variations at Bangalore. —*By* A. VENKATA RAO TELANG.

The paper embodies observations taken at Bangalore over a period of five years with breaks.

The following conclusions are drawn from a study of three series of observations :—

(i) The potential, usually positive, moves to negative prior to a fall of rain, and fluctuates violently during the rain-fall.

(ii) When the sky is fully or nearly fully covered with clouds the potential is very low.

(iii) The potential falls often steeply just before or after midnight, reaching a minimum before sun-rise.

(iv) The cumulus clouds, often characteristic of the local thunderstorms in April and May, cause the potential to reach both high positive and negative values.

On the Action of an Electric Field on Aero-Sols.—*By* P. N. GHOSH.

The purification of a gas from its suspended solid impurities of the nature of smoke, dust, etc., by the application of electric field was first practically proposed by Cottrell in America in 1906. The study of the phenomena, when these particles were of a conducting nature, have been taken up by Möller, Püning, Dürer and Thien, and by several other workers with considerable amount of success. The application of a suitable potential gradient in the region containing these particles has been worked out.

In the case of liquid particles, however, the results had been quite anomalous and the application of the field in the mechanism of precipitation has not met with the same amount of success.

The present paper deals with the phenomena of precipitation and coalescence of fine liquid particles suspended or mechanically carried in gases or vapours. The mechanism of spraying air or gases through ionised liquids accounts for the production of large ions of various mobilities, as has been observed in Nolan and others. These large ions serve as nucleii on which the fine droplets condense and under suitable potential gradient are driven on the charged plates. In the case, however, of non-conducting liquids, the potential gradient must be sufficiently high to ionise the air. The case of Turpentine, Benzine and some of the essential oils have been investigated.

The vapour pressure of formaldehyde at temperatures between its melting and boiling points.—*By* J. C. GHOSH *and* SASHIBHUSAN MALI.

In connection with some experiments on conditions of equilibrium in the following technical gas reactions

$$CH_3OH \rightleftarrows HCHO + H_2$$
$$HCHO \rightleftarrows CO + H_2$$

it was considered necessary to determine the chemical constant of formaldehyde. The experiments are beset with many difficulties, the chief one being due to the fact that on raising its temperature liquid formaldehyde possesses the unique property of passing into a solid state, whose vapour pressure is negligible. With special precautions it has been possible to obtain liquid formaldehyde in a stable and pure condition and its vapour pressure has been determined between −95° to −21° in a liquid air thermostat. The results are given below:—

	T. centigrade	V. P.	λ_0
(1)	−95	14 mm.	3248 calories.
(2)	−52·2	247 ,,	3254 ,,
(3)	−50·87	261 ,,	3252 ,,
(4)	−47·5	294 ,,	3329 ,,
(5)	−38·5	419 ,,	3310 ,,
(6)	−31·8	537 ,,	3278 ,,
(7)	−20·5	789·2 ,,	....

λ_0 has been calculated from the equation of Nernst

$$\log p = -\frac{\lambda_0}{RT} + 1{\cdot}75 \log T + C.$$

The mean molecular latent heat of vaporisation is *3275.*

A variation of a solution of Laplace's equation.—*By* K. B. MADHAVA.

Since the harmonic property of a function is in no manner dependent upon any particular set of axes, it suggests that some useful transformations (preferably of orthogonal axes having the same origin) may be employed and a variation of the solution, simpler to manipulate, obtained. To Whittaker's solution, which is the three-dimensional analogue of the ordinary Complex Variable, a general transformation of axes is suggested in this paper, and one or two illustrations (a Zonal Spherical Harmonic and a Bessel function) are added of the power and scope of the simplification attained.

Some Infinite Series and Products.—*By* M. BHEEMASENA RAO *and* M. VENKATARAMA AYYAR.

In a prefatory note, the authors remark that some of the results arrived at in the paper are already known but that the method adopted by them is simpler, as it does not involve modular equations. There are several results, also, which they believe to be new.

Starting with the well-known integral

$$\int_0^\infty \frac{\sin\,(bx)dx}{e^{2\pi x}-1}=\frac{1}{2}\left(\frac{1}{e^b-1}-\frac{1}{b}+\frac{1}{2}\right)$$

(under certain conditions for b), and using another well-known result

$$\underset{n\to\infty}{Lt}\int_0^\infty \frac{\sin\,(2n+1)x}{\sin x}\,f(x)dx\;=\;\frac{\pi}{2}\left[\,f(0)+2f(\pi)+2f(2\pi)+\;\cdots\;\right],$$

and some further transformations, they obtain the formula

$$\left\{\frac{1}{e^{2a}-1}+\frac{2^{2n+1}}{e^{4a}-1}+\frac{3^{2n+1}}{e^{6a}-1}+\ldots\right\}+\left(\frac{\pi}{a}\right)^{2n+2}.\,(-1)^n\,.\,\left\{\frac{1}{e^{2\pi^2/a}-1}\right.$$

$$\left.+\frac{2^{2n+1}}{e^{4\pi^2/a}-1}+\frac{3^{2n+1}}{e^{6\pi^2/a}-1}+\ldots\right\}=\frac{B_{n+1}}{4(n+1)}\,.\left\{\left(\frac{\pi}{a}\right)^{2n+2}+(-1)^n\right\}.\quad(1)$$

for all values of n, except zero, in which case we have to add $-1/4a$ to the R.H.S.

Putting $a=\pi$, this gives as a special case formulæ already obtained by Mr. S. Ramanujan (*vide* No. 13, Vol. XIV, J.I.M.S., p. 120, Vol. IV, J.I.M.S.).

On differentiation with respect to a, (1) leads to

$$\pi\left\{\;\text{cosech}^2\;(\pi)+2^{4m}.\,\text{cosech}^2\,(2\pi)+3^{4m}.\,\text{cosech}^2\;(3\pi)+\;\ldots\ldots\right\}$$

$$=4m\,.\left\{\frac{B_{2m}}{8m}+\frac{1^{4m-1}}{e^{2\pi}-1}+\frac{2^{4m-1}}{e^{4\pi}-1}+\frac{3^{4m-1}}{e^{6\pi}-1}\;+\;\ldots\ldots\right\}$$

a well-known result of the late Mr. S. Ramanujan, F.R.S. (*vide* result No. 8 on p. 89, No. 3, Vol. XIV, J.I.M.S.).

A similar procedure with a modified form of (1) leads to

$$\frac{\pi}{2}\left\{\text{sech}^2\left(\frac{\pi}{2}\right)+3^{4m}\;.\;\text{sech}^2\left(\frac{3\pi}{2}\right)+5^{4m}\;.\;\text{sech}^2\left(\frac{5\pi}{2}\right)+\;\ldots\ldots\right\}$$

$$=4m\;.\left\{\frac{B_{2m}\,(2^{4m-1}-1)}{8m}+\frac{1^{4m-1}}{e^{\pi}+1}+\frac{3^{4m-1}}{e^{3\pi}+1}+\frac{5^{4m-1}}{e^{5\pi}+1}+\;\;\ldots\right\},$$

a new result, parallel to that of Mr. Ramanujan's above.

Integrating (1) with respect to a, in the case $n=0$ the authors obtain the result

$$\frac{(1-e^{-2\pi a})\,(1-e^{-4\pi a})\,(1-e^{-6\pi a})\;\ldots\ldots}{(1-e^{-2\pi/a})\;(1-e^{-4\pi/a})\;(1-e^{-6\pi/a})\;\ldots\ldots}=a^{-\frac{1}{2}}\,.\,e^{\frac{\pi}{12}\left(a-\frac{1}{a}\right)}\qquad(2)$$

By giving special values to a, (2) may be utilised to obtain a series of results, of which the authors give a table.

Cyclotomic Sexi-section.—*By* A. A. Krishnaswamy Ayyangar, M.A., L.T.

It is well known that the roots of the cyclotomic equation

$$x^{n-1}+x^{n-2}+\;\ldots\;+x^2+x+1=0$$

can be divided into 6 periods of p terms each when n is a prime of the form $6p+1$. In this note, the author investigates the sextic equation satisfied by these periods. The method followed is in some respects analogous to that usually adopted in deriving the cubic equation of periods when n is a prime of the form $3p+1$.

The sextics derived are

$$\text{(i)}\quad x^6 + x^5 - \frac{5(n-1)}{12}x^4 - \left[\frac{1}{9}na' + \frac{(n-1)(3n+10)}{108} - An\right]x^3$$
$$+ \left[n\Sigma AB + \tfrac{1}{2}nb(B-C) + \tfrac{1}{2}nAa' - \frac{n(n-1)}{72}a' - \frac{(n-1)^2(n-5)}{432}\right]x^2$$
$$- \left[nBC(a'-1) + \tfrac{1}{2}na'\left(A^2 - \frac{\overline{n-1}^{\,2}}{432}\right) + \tfrac{1}{2}nb(B-C)\left(3A - \frac{n-1}{12}\right) + \frac{(n-1)^3}{1296}\right]x$$
$$+ \frac{(n-1)^4}{36^3} - \tfrac{1}{2}nb\Pi(A-B) + \tfrac{1}{2}nABC(3a'-2) + \frac{n(n-1)a'}{24}\left[\frac{(n-1)^2}{648} - \Sigma AB\right] = 0,$$

when n is a prime of the form $12n+1$.

$$\text{(ii)}\quad x^5 + x^5 + \frac{n+5}{12}x^4 - \left[\frac{1}{9}na' + \frac{3n^2-47n-10}{108} - An\right]x^3$$
$$+ \left[n\Sigma AB + \tfrac{1}{2}nb(B-C) + \tfrac{1}{2}nAa' - \frac{n(n-7)}{72}a' - \frac{(n-1)(n^2-18n+5)}{432}\right]x^2$$
$$- \left[nBC(a'-1) + \tfrac{1}{2}na'\left(A^2 - \frac{\overline{n-7}^{\,2}}{432}\right) + \tfrac{1}{2}nb(B-C)\left(3A - \frac{n-7}{12}\right) - \frac{n(n-1)}{6}A\right.$$
$$\left. + \frac{(n-1)(7n^2-80n+1)}{1296}\right]x$$
$$+ \frac{(n-7)^3}{36^3}(3na'+n-1) - \frac{(n-1)^3(n-19)}{36^2 \cdot 2} - \tfrac{1}{2}nb\Pi(A-B)$$
$$+ \frac{n}{6}\left[n-1-\frac{n-7}{4}a'\right]\Sigma AB + \tfrac{1}{2}nABC(3a'-2) = 0\,,$$

when n is a prime of the form $12n+7$.

These formulæ reveal some errors in the numerical calculations of the sextics for the primes 31, 43 and 61 published by Pandit Oudh Upadhyaya, Research Scholar, Lucknow University, in the Tohoku Mathematical Journal (Vol. 21, Nos. 1 and 2, July 1922, and Vol. 22, Nos. 3 and 4, 1923) and show how, what must have taken otherwise several days to calculate, can now be computed in a few minutes.

A Statistical Study of Examination Marks: II.—*By* P. V. SESHU AYYAR *and* S. R. RANGANATHAN.

This is a continuation of the paper on "A Statistical Study of Some Examination Marks" read before the Ninth Science Congress. Some further material has been examined. It confirms our anticipation that the correlation between any subject and English Composition will be different from that between that subject and the whole of English. It is suggested that it will be more suitable to base, on the former, the measure for the part played by power of expression in answering the questions in the various subjects.

It is found that the standard deviation in the recent years has appreciably fallen down in the case of English and remarkably increased in the Science subjects. Some conjectures are made as to the cause and significance of this phenomenon.

Rational Approximations.—*By* T. VIJIARAGAVAN.

(Notation: θ denotes an irrational number $\equiv (a_1 : a_2, a_3, \ldots a_n, \ldots)$.

$$\lambda(\theta, n) \equiv \left| \theta - \frac{p_n}{q_n} \right|^{-1} \cdot \frac{1}{q_n^2},$$

$$\text{and} \quad K(\theta) = \overline{\lim_{n \to \infty}} \left| \theta - \frac{p_n}{q_n} \right|^{-1} \cdot \frac{1}{q_n^2} \Bigg).$$

Main theorems established in the paper:—

I. If s is the largest number occurring an infinity of times among the a's of θ, then,

$$\sqrt{s^2+4} \leq K(\theta)^2 \leq \sqrt{s^2+4s}$$

II. Of the set $\{K(\theta_s)\}$, where s is the largest number occurring among the a's, $\sqrt{s^2+4}$ is an isolated point and $\sqrt{s^2+4s}$ is not an isolated point.

III. If $K(\theta) = l$ (θ, any nonquadratic), then l is a limit point of the set $\{K(\theta)\}$ (θ, quadratic).

IV. If l is a limit point of the set $\{K(\theta)\}$ (θ, quadratic), it is also a limit point of the set $\{K(\theta)\}$ (θ, nonquadratic), and an infinity of nonquadratic θ's can be constructed having their $K(\theta)$ equal to l.

V. Merkoff states that if θ is nonquadratic then $K(\theta) \nless 3$. Now, the sequence of numbers $\phi_1, \phi_2, \ldots \phi_r \ldots$

where $\phi_r = \Bigg(\underbrace{\overset{\times}{2}\,2\,.\,.\,.\,.\,1\,\overset{\times}{1}}_{2r}\Bigg)$ are such that $K(\phi_r) \to 3-\epsilon$.

From IV it will follow that Merkoff's result cannot be improved.

Other numerical results, which are of practical importance, are also deduced.

Spectrophotometry of the Zeeman effect.—*By* WALI MOHAMMAD.

Extremely bright and sharp spectrum lines were produced by means of a Vacuum arc consisting of a Wehnelt Cathode and an anode of a given material. This source was placed in very weak magnetic field which could be varied and the Zeeman effect was observed by means of an Echelon Grating consisting of 35 plates. Photographs were taken before the lines showed any separation and the distribution of the intensity in the line was studied by means of a Hartmann Spectrophotometer in which the tint at any point on the photographic plate is compared with that on a standard plate. The observations on the red line of zinc $\lambda = 6364$ showed that even with the weakest magnetic field employed (290 Gauss) the line shows two components not quite symmetrical either in intensity or in position and this dissymetry is maintained even when the field strength is increased.

An explanation of the dissymetry is sought on the "coupling" theory of Voigt and on the modern theory of Bohr.

On intensity estimates of spectral lines.—*By* E. P. METCALFE.

Attention is directed to the diversity existing among estimates by different observers of the relative intensities of spectral lines, particularly in the case of components of complex lines. A probable cause of these discrepancies lies in the use of radiating sources of different forms and operating under different conditions. Differences in the selective absorption of different lines by the luminous vapour of the source itself may greatly modify the relative intensities of the lines radiated, especially where the source presents any considerable thickness of luminous vapour in the line of sight. The effect is illustrated by photographs of spectral lines emitted by thick and thin layers respectively of luminous gas. In order to secure definite information regarding the relative intensities, measurements should be carried out only with sources which present thin layers in the line of sight and in which the luminous column is not surrounded by gas under reduced conditions of excitation. A form of vapour lamp satisfying these and other necessary conditions is described. It is pointed out that the relative enhancement of a normally weak component of a complex line under certain conditions may cause an apparent shift of the line in a spectrum in which the line is not resolved.

The Vacuum Arc Spectra of Lithium and Rubidium.—*By* SNEHAMOY DATTA.

Lithium.

1. The structure of the Lithium line λ6708 has been examined at different pressures. The gradual narrowing of the line with decreasing pressure (shown in the accompanying table) has led to the conclusion that the line is really a singlet, the varying width of the apparent doublet being due to the varying character of the absorption.

TABLE.

Stage.	λ.I.A.	Δλ.	Mean λ	REMARKS.
I	6708·181 07·499	0·682	6707·840	Looks like broad reversal, Violet compt. Showing wings.
II	6708·109 07·580	0·529	6707·844	Looks like doublet.
III	6708·080 07·604	0·476	6707·842	Ditto.
IV	Only separations.	0·402	..	Doublet components. Show fine reversals.
V	Measured	0·332	..	Ditto.
VI	6707·950 07·728	0·222	6707·839	No reversal of the components.

(The stages IV and V are identical to what McLennan has regarded as quartets and show the same order of separation.)

2. The subordinate series lines λ6104 and λ4973 flashed out showing a faint reversal giving the deceptive appearance of a close doublet. They are ordinarily single lines and their photographs have been obtained both with and without the reversal, when the subordinate series lines flashed out as reversed lines the red Lithium line (λ6708) corresponded to stage I, and at this stage the second member of the principal series λ3232 stand as a fine reversal. At higher stages of exhaustion no reversal was noticed and the line was unresolved even in the third order. These are fresh facts which confirm the view that Lithium lines previously described as doublets are really singlets, their doublet appearance being due to the fine reversals which are shown even at low pressure.

3. Definite improvements in the measures of the line have been-

obtained by using the vacuum arc giving well-defined lines as the source and obtaining the measures from higher order spectrograms.

Rubidium.

1. Existence of the satellites to the diffuse series of Rubidium previously doubted have been established in course of the present experiments by observing for the first time satellites to the fourth and the fifth member. The separation of the satellites from the respective more refrangible component is the same as the separation of the S pairs, thus proving the correctness of the allocation.

2. Definite improvements in the measures, as proved by the constancy of the separations of pairs of lines, have been obtained by the use of the vacuum arc giving well-defined lines as the source and obtaining the measures from higher order spectrograms.

Polarisation of Resonance Radiation in Weak Magnetic Fields.—*By* K. R. RAMANATHAN.

Prof. R. W. Wood and Mr. A. Ellett have recently obtained some very remarkable results (Proc. Roy. Soc., Vol. 103, p. 396) on the polarisation of the resonance radiation of the vapours of mercury and sodium in weak magnetic fields. A theory of the effect has been suggested by Dr. Charles Darwin, but it is admittedly unsatisfactory. It seems to the writer that a simple explanation of the observed phenomena can be put forward on the following lines.

According to Bohr's theory of spectra, the emission of radiation by an atom is preceded by the transference of an electron from its normal orbit to a stationary orbit of higher energy, and the radiation takes place during the return of the electron from the orbit of higher energy to one of lower energy. In the case of resonance radiation, the exciting agency is the electric intensity in the incident light-wave, and if the incident light is plane-polarised, we may expect that when first excited, the major axis of the approximately elliptical orbit of the electron would lie in the direction of the electric vector in the incident light, or at any rate, the component of the vibration along that direction would be greater than in perpendicular directions. From Bohr's Correspondence Principle, the intensity and state of polarisation of the resonance radiation in any direction can be co-ordinated with the configurations of the orbits and the amplitudes of the vibration components in appropriate directions. If a time long in comparison with the mean interval between two molecular collisions (or with the period of precessional rotation of the orbit due to the forces in the atom) elapses before the return takes place, the orientation of the orbit would have been rendered random and the radiation would be unpolarised. Otherwise, there would still be partial polarisation, the actual amount depending on the nature of the radiating atom and on the frequency and nature of the molecular collisions.

The effect of the magnetic field is two-fold; one is to tilt the orbit of the electron at right angles to itself, and the other is to superpose on the motion of the electron a uniform rotation (precession) of the orbit about the direction of the magnetic field, the rate of rotation being $He/2mc$. When we take these two factors into account and assume that the time during which an atom remains in the excited condition is of the order of precession of the electron orbit, all the facts of polarization observed by Wood follow.

A little consideration would show that Wood's observations with Sodium vapour and also his further observation in the case of mercury vapour, that the resonance radiation nearly in the line of the exciting beam when subjected to a transverse magnetic field shows strong polarisation, are in agreement with the indications of theory.

The influence of the length of the radiating column on the width of spectral lines.—*By* B. VENKATESACHAR.

A finite length of low density luminous gas in a steady state of excitation is considered. The problem is discussed under the following heads:—

(1) Intensity distribution in a simple line radiated by a luminous column of finite length.

(2) Evaluation of the energy content of a simple line in the radiation from such a column.

(3) The visibility of the interference fringes produced by a simple line in the radiation from a column of finite length in an interferometer of the Michelson type.

(4) Numerical calculations in specific cases.

The bearing of the investigation on temperature determinations of nebulae by interference methods and on other allied problems is discussed. Experimental evidence in support of some of the results is adduced.

On the emission and absorption of conducting mercury vapour.—*By* E. P. METCALFE *and* B. VENKATESACHAR.

The paper deals with the work done by the authors in continuation of that published by them in 1921, one of the objects of the investigation being further to test the behaviour of the satellite ·09 of the mercury green line 5461A. Theoretical considerations led to the conclusion that by sufficiently increasing the length of the absorbing column and diminishing the current density, its own luminosity may be indefinitely reduced while the total absorption produced by it may remain considerable. Accordingly a discharge tube was constructed affording an absorbing arc column of one metre in length, consisting of two 50-centimetre arcs discharging to a common kathode in a subsidiary ionising arc.

(1) All satellites of the 5461A group, except −·24, are heavily absorbed under suitable conditions. The line −·24 is slightly, but perceptibly, absorbed.

(2) The ratio of emission to absorption is fairly constant for all the satellites except −·24, for which last the ratio is very much greater.

(3) All the resolved satellites, except −·24, have been reversed on a continuous background produced by a high pressure vapour lamp of special construction.

(4) The satellites of the line 4359A ($1p_2 - 1s$), a line similar in complexity to 5461A, have been similarly reversed.

(5) The yellow line 5769A and its two satellites (+ ·044 and − ·050) and the line 5790A have also been reversed. The absorption centres for these lines are the same, being atoms in the energy level 1 P.

The line 5790A, the brighter of the two yellow lines, has the smaller coefficient of absorption, a fact explainable by the association with the main line of close components which, like −·24 of 5461A, are feebly absorbed.

The last part of the paper is taken up with a discussion of the possible isotopic origin of some of the satellite lines.

Absorption of Potassium Vapour at high pressures and satellites accompanying the members of the Principal Series.—*By* A. L. NARAYAN *and* D. GUNNAYYA.

In a paper communicated to the Mathematics and Physics Section of the Congress last year, the authors described some experiments on the absorption of K-vapour. The present paper records the results of further experiments conducted in the laboratory since then. These experiments not only confirmed the existence of most of the lines belonging to the associated series previously observed by the authors, but also ;

(1) the line 4831 A.U. observed in the previous experiments was found to be, in intensity, next to 4641 and 4642. Attempts to correlate this line showed that this is 1,P–8,P. According to the quantum theory absorption of this line is the result of electronic transition from the 1,P orbit to the 8,P orbit, which is an exception to the Bohr Principle of Selection, and it is possible that the principle is broken down at these high pressures owing to the disturbing field of the neighbouring atoms. Further, the valence electron is first thrown by '*thermal agency*' out of the ground orbit into 1,P orbit further removed from the nucleus ;

(2) the line 4120 observed by Datta, in Rayleigh's vacuum arc lamp as a faint line and included by Fowler among unclassified lines, has been distinctly reversed ;

(3) new lines which do not correspond to the emission lines of K and which are simply satellites clustered together within a small compass about the principal lines, were observed. These new lines become with the increase of vapour density larger in number and more and more diffuse P containing at the highest pressure used by the authors four satellites of wave-lengths 3434·6, 3461·65, 3468·45 and 3482·15 A.Us.

Note on the Violation of the Selection Principle and the absorption spectrum of Rubidium vapour.—*By* SNEHAMOY DATTA *and* ANIL RANJAN DAS.

The absorption of the 1*s*–3*d* line of Potasium has been secured in a tube heated in a gas furnace. This precludes the influence of any external electric field caused by the previously adopted electrical heating arrangement. Visually the absorption of the line has been observed at quite a low pressure, so that the question of the influence of electric field of atomic origin probably does not arise. Thus the objection raised by some that the line has been absorbed under the condition analogous to that in the Stark effect falls through and it may be maintained that here is a real case of the violation of the Selection Principle as stated at present.

The absorption spectrum of Rubidium Vapour has been photographed. A preliminary survey shows that the number of members of the series has been considerably raised and that several more members have now been resolved into their components.

The absorption of the 1*s*–3*d* line for Rubidium has also been secured.

The Adsorption of a constituent Ion by an insoluble salt in its Relation to the lattice Energy of the Ion and to the Formation of Liesegang's Rings, Part I.—*By* J. N. MUKHERJEE *and* H. L. ROY.

The adsorption of various ions by well-washed precipitated lead chromate has been followed by electro-osmotic experiments. The results have been discussed from the point of view of the formation of Liesegang's rings, of the solubilities of the various lead salts and of the lattice energy of the ions. The intensity of the adsorption of the ion depends on factors other than the lattice energy, or the solubility. It is probable that the energy changes in the hydration of the ions and on the surfaces have to be taken into consideration.

Studies in Phototropy.—*By* Y. VENKATARAMAIAH, BH. S. V. RAGHAVA RAO, A. JANAKI RAM *and* T. VARAHALU.

A brief historical review of the theories of work done on this subject is given. The phototropy is observed in a number of compounds of the formula $HgXY$ and $Hg_3S_2X_2$ where X and Y represent different groups on radicles. A photographic plate is found to be affected in the dark by phototropic compounds after they are exposed to direct sun light for some time. It is found that phototropic compounds in the process of reversion to their original state in the dark give out radiations in infrared region and the radiations are being analysed

Active Gases.—*By* Y. VENKATARAMAIAH, BH. S. V. RAGHAVA RAO *and* M. V. NARASIMHASWAMY.

A brief review of the previous work on the subject is given. The following new methods for the formation of Active Hydrogen and Chlorine are described :—

(1) Silent electric discharge.
(2) Explosion of hydrogen and oxygen with a little excess of hydrogen.
(3) Surface combustion of hydrogen and oxygen on platinum.
(4) High tension arc.
(5) High temperature arc.
(6) Decomposition of metallic hydride.
(7) By electrolysis.
(8) Diffusion through palladium and platinum.

The physical and chemical properties of these gases are also described.

Statistical law of Emission of Electrons from Hot Bodies. —*By* S. C. ROY.

In this paper, it is shown how to work out a law of thermionic emission as a theorem in statistical mechanics on the general principles of the quantum theory. Thus, if the electrons inside a metal-crystal be supposed to form space-lattices like the atoms, then their energy-content may be written as

$$E_f = \sum_{i=1}^{i=3S} \frac{h\nu_i}{e^{\frac{h\nu_i}{k\tau}} - 1}$$

Owing to small mass, the electrons possess very high frequencies and hence E_f is vanishingly small even at tolerably high temperatures.

In an assembly of N electrons, if $1, 2 \ldots n$ be in the gaseous state and $(n+1), \ldots . N$ be in the solid state, the number inside the solid is $S = N - n$. Further, if q's and p's specify the positional and the momenta co-ordinates and χ_0 denotes the work done in taking an electron out of the solid to the gaseous state, the energy of the 'gas-electrons' may be written as

$$Eg = \frac{1}{2m} \sum_{i=1}^{i=3n} p_i^2 + n\chi_0 .$$

Also, using normal co-ordinates for electrons inside the solid, their energy content is

$$Ef = \frac{1}{2m} \sum_{i=1}^{i=3s} (p'^2_i + w_i^2 q'^2_i) .$$

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The probability that the electrons 1, 2, ... n are in the gaseous state and the atoms $(n+1)$, . . . N are in the solid state is, by Boltzmann's theorem,

$$Wn = A \int \epsilon^{-\frac{1}{k\tau}(Ef+Eg)} \,.\, dq_1 \ldots dp_{3n} \,.\, dq'_1 \ldots . dp'_{3s}$$

Assuming that E_f is zero for the electrons and $\int dq'_1 \ldots dp'_{3s} = (h)^{3s}$,

$$\omega n = A\epsilon^{-\frac{n\chi_0}{k\tau}} \,.\, V^n \,.\, (2\pi mk\tau)^{\frac{3n}{2}} \,.\, h^{3(N-n)} \,.$$

N electrons can be formed into groups of s and n in $\frac{N!}{n!\,s!}$ ways, while s electrons inside the metal-crystal can be arranged in lattices in $s!$ ways. Hence the total probability of forming the specified assembly is

$$W_n = A \,.\, \frac{N!}{n!} V^n \,.\, \epsilon^{-\frac{n\chi_0}{k\tau}} \,.\, (2\pi mk\tau)^{\frac{3n}{2}} \,.\, h^{3(N-n} \,.$$

The state of equilibrium of the system corresponds to the state of maximum probability for which $\frac{\partial}{n\partial} \log W = 0$. Hence using Sterling's approximation $n! = n \log n - n$, it now easily follows that

$$\log \frac{n}{v} = -\frac{\chi_0}{k\tau} + \log \frac{(2\pi mk\tau)^{\frac{3}{2}}}{h^3} \,.$$

The number emitted per second per unit area is, by the kinetic theory of gases,

$$n' = (1-r) \,.\, \frac{n}{V} \,.\, \left(\frac{k\tau}{2\pi m}\right)^{\frac{1}{2}}$$

$$= (1-r)\, \frac{2\pi mk^2}{h^3} \,.\, \tau^2 \,.\, \epsilon^{-\frac{\chi_0}{k\tau}} \,,$$

where r is the fraction of the incident electrons sent back by reflection.

Next, according to Richardson's statistical theory of auto-photo-electric effect,

$$\frac{c}{4} \int^{\infty} \frac{8\pi}{c^3} \,.\, h\nu^3 \,.\, \epsilon^{-\frac{h\nu}{k\tau}} \,.\, E\nu \,.\, F(\nu) d\nu = \frac{2\pi mk^2}{h^2} (1-r) \,.\, \tau^2 \,.\, \epsilon^{-\frac{\chi_0}{k\tau}} \,,$$

where $E\nu =$ emissivity of radiation for frequency ν; and

$F(\nu) =$ number of electrons liberated by the absorption or emission of unit quantity of radiant energy.

The above equation is satisfied by

$E\nu.\, F(\nu) = 0$, when $\chi_0 > h\nu > 0$;

and $\quad E\nu \,.\, F(\nu) = (1-r) \,.\, m \,.\, \frac{c^2}{h^2\nu^2} \left(1 - \frac{\chi_0}{h\nu}\right)$, when $\chi_0 < h\nu < \infty$.

Also, the mean kinetic energy of the electrons emitted by light of frequency ν is given by

$$\frac{c}{4} \int_0^{\infty} T\nu \,.\, E\nu \,.\, F(\nu) \,.\, \frac{8\pi}{3} \,.\, h\nu^3 \,.\, e^{-\frac{h\nu}{k\tau}} = 2k\tau \,.\, (1-r) \,.\, \frac{2\pi mk^2}{h^3} \,.\, \tau^2 \,.\, \epsilon^{-\frac{\chi_0}{k\tau}} \,.$$

Using the value of $E\nu \,.\, F(\nu)$ in the above expression,

$$T\nu = h\nu - \chi_0 \,, \text{ when } \chi_0 < h\nu < \infty \,.$$

At the absolute zero, the electrons are emitted with zero kinetic energy ; hence, $0 = h\nu_0 - \chi_0$,

where, $\nu_0 =$ frequency of the photo-electric threshold.

Thus,
$$I = n'e = \frac{2\pi mek^2}{h^3}(1-r) \,.\, \tau^2 \,.\, \epsilon^{-\frac{h\nu_0}{k\tau}} ,$$

which is the law now proposed.

Absorption of electrically luminiscent Potassium Vapour.—*By* A. L. NARAYAN *and* G. SUBRAHMANIAM.

By distilling the vapour into a special discharge tube under a high vacuum, and by passing a feeble discharge through the vapour at about 400° C, absorption of the vapour in the infra-red was studied with a mirror spectrometer and Paschen galvanometer to find if the vapour shows absorption in the Subordinate and Bergman series. For this purpose Sun light was used as source. And it was found that the vapour exercises feeble but distinct absorption at $1{\cdot}5\mu$, the first member of the Bergman series, but no absorption at $1{\cdot}25\mu$ and $1{\cdot}18\mu$ the first members of the subordinate series. The failure to detect absorption in the subordinate series may be due to the fact that excitation is sufficient to maintain a fair proportion of the electrons in the 3,d orbit. Further the fact that in this case a certain excitation is necessary to provoke absorption, is in accordance with the statement made by the authors that in the case of the alkalies energy necessary for excitation of the spectral lines increases in the order Principal, Diffuse, Sharp, and Bergman series.

Structure of 1s–3d of Potassium.—*By* A. L. NARAYAN.

On account of the sharply defined nature of this pair in the absorption spectrum and on account of the interest that centres round this, the structure of this line was studied with a Lummer Plate of about 300,000 R.P. at 4640. For this purpose potassium vapour in a high state of purity was distilled into the discharge tube under a high vacuum. The tube being maintained at about 350° C., it was found that 1s–3d came out with moderate intensity, when a discharge from a 6-inch coil was passed through the tube. The diffraction pattern showed no satellites. But the diffuse nature of the lines shows that with an instrument of higher resolving power each of the principal lines resolves possibly into two lines one of them being faint, in which case, separation will probably be in accordance with Bohr's, at any rate not in accordance with McLennan's view.

On the condition of Zero-residuality of six points on a non-singular cubic.—*By* M. LAKSHMANAMURTHI *and* B. S. MADHAVARAO.

The problem of finding the conditions for six points on a cubic to lie on a conic are attempted without having recourse to Elliptic Functions. A geometric solution is first offered and then follows the general analytical method.

On the collision of spherical bodies at very low velocities.—*By* D. B. DEODHAR.

The most interesting problem about the dissipation of energy when bodies collide with extremely small velocities has been studied on an extended scale; experimental arrangements being practically on the lines of Professor Raman. Different diameters, dissimilar materials or different media in which impacts take place do not produce any influence on the change in the co-efficient of restitution at minimal velocities. The duration of impact in water is always appreciably larger than in air, and this fact calls for a modification of the duration formula given by Hertz. It appears that during the process of impact, molecular displacement takes place in the surface layer and that the co-efficient of restitution is largely associated with dissipation of energy.

On a Method for the determination of Surface-Tension.—*By* BARKAT ALI.

In this paper, a modification, of the ordinary method of measuring surface-tension by observing the capillary rise is described. The modification consists in measuring by means of a sensitive manometer the pressure which must be applied to the surface of the meniscus in order to depress it to the level of the horizontal surface of the liquid outside. In practice, it was formed more convenient to depress the meniscus to a fixed mark on the capillary, the depth of this below the free surface being determined accurately.

The paper sets out the advantages of the method. The results obtained with water, benzene, methyl alcohol and ethyl alcohol are respectively 71·32, 28·10, 23·30 and 21·32 dynes per centimeter at 29·5°C.

Experiments on the action of the Bunsen aspirating pump.—*By* C. K. SUNDARACHAR.

The paper describes certain experiments on the action of the Bunsen aspirating pump under varying conditions. The conclusion arrived at by Will. C. Baker (Phy. Rev., Vol. XIV, p. 228) has been confirmed by a different experiment maintaining an excess of pressure in the reverse direction. A new experiment determining the relation between the rate of suction of the gas and the velocity of the liquid stream under different pressure gradients is described.

On the Spectrum of Neutral Helium.—*By* A. S. GANESAN.

In this paper, which will shortly appear in the Astrophysical Journal, Silberstein's Combination formula for the helium lines is further discussed and the contention that the agreements between the observed and calculated frequencies are purely fortuitous is upheld.

Effect of a Retarding Plate on Interference Fringes in White Light.—*By* NIHAL KARAN SETHI.

White-light fringes observed in Michelson's Interferometer are but few in number, show marked colours and are usually seen as straight bands. But the mere introduction of a *thick* glass plate in the path of one of the interfering beams is shown to bring into view literally some *thousands* of them in the form of circular rings. Any attempt at partially monochromatising the light *diminishes* their number. This increase in number is due not to achromatisation of any sort but rather to the opposite effect of the different parts of the spectrum producing interference in different places. This is demonstrated by spectroscopic examination of the rings and the corresponding formulae quantitatively verified by using them to determine the dispersion of the glass plate employed. Two other examples of this peculiar dispersion of white-light fringes are quoted from a former paper by the author and it is pointed out that the increase in the number of white-light fringes observed by Wood on introducing sodium vapour into the interferometer path also involves the same process and is not due to achromatisation as suggested by him.

The visibility of these fringes measured in terms of the total illumination in the maxima and minima is very poor. They are seen merely by colour-contrast. The colour has been calculated and is shown to be poorer than even the first order white of Newton's scale and yet the human eye is able to distinguish it quite clearly.

On the Colours of Nobili's Rings and of tarnished metal surfaces.—*By* B. N. Chuckerbutti.

When a polished plate of platinum, silver or brass connected with one pole of a battery is immersed horizontally in a solution of copper sulphate, or any other suitable electrolyte, e.g., lead and manganous acetate or sulphate copper acetate, etc., and a vertical platinum wire connected with the other terminal of the battery, is held in the solution about a millimetre distant from the plate, then on passing a strong current through the solution (about 2 amp.), beautiful rings are formed upon the metal plate with the platinum point as the centre. The rings show beautiful colours and the colour sequence is the same as in case of Newton's Rings in white-light.

The old explanation of such rings is that they are due to the interference of light by thin surface films deposited during electrolysis. The colours however resemble the colours of tarnished metal surfaces investigated by the author (Proc. of Ind. Assoc. for the Cultivation of Science, Vol. VII, Parts III and IV, 1922).

On examining these plates with a high power microscope, the film reveals a granular structure and the particles near the centre are bigger (diameter 500 $\mu\mu$) than the particles at a distance (diameter 275 $\mu\mu$).

The other observations by the author supports the view that the colours are mostly due to the diffraction of light by the granular deposit formed upon the plate.

In a previous paper (Proc. of Ind. Assoc. for the Cultivation of Science, Vol. VII, Parts III and IV), the nature of the colours of tarnished metal plates has been discussed. The present paper gives a verification of the theory put forward in that paper for the case when the light is incident normally upon different metal plates.

Some experiments with Osglim lamps.—*By* B. N. Ghose.

The high resistance in series with the lamp is taken out and its utility is discussed at length.

A p.d. of about 200 volts between the electrodes of lamp makes it useless for ordinary purposes. The spoilt lamp is connected with the secondary of an induction coil when the bulb begins to glow again. The spectrum of an ordinary Osglim lamp is compared with that run by an induction coil. It appears that at higher voltage, absorption of the gas takes place due to the high current passing through the lamp and hence the critical voltage is increased.

The experiment of Messrs. Pearson and Anson as described in the Proceedings of the Physical Society of London, Vol. 34, page 204, on the flashing discharge of the lamp is verified on an extended scale and the formula $T=KR \log \dfrac{V-b}{V-a}$ is used for the comparison of very high resistances with satisfactory results.

A number of experiments were carried out with a variable high resistance in series with the lamp from which it appears that ordinarily an intermittent current of very high frequency passes through an Osglim lamp.

The ratio of the frequencies of the two electrodes of the same lamp is approximately one-fourth the ratio of their area. The critical voltage is nearly the same with both the electrodes.

On the effect of drawing on the co-efficient of rigidity of Eureka wire.—*By* G. B. DEODHAR.

As a result of a long series of experiments by the author, it has been observed that the co-efficient of rigidity, η, of Eureka wire decreases with decreasing radius of the wire when it is successively drawn through a draw-plate. Within certain limits the law of variation of η is given by the empirical formula $\eta = Ae^{\beta R}$ where $A = 5{\cdot}13 \times 10^{11}$ and $\beta = 1{\cdot}29$. The decrease in rigidity is explained by the action of drawing on the crystalline aggregates in the surface layers which are the seat of maximum torsional strains.

Scattering of light in rock-salt.—*By* LALJI SRIVASTAVA.

1. (*a*) The experimental value of the intensity of scattering of light in rock-salt in a direction perpendicular to the incident beam is measured by a photographic method and at 26°C is found to be 53·7 times that of dust free air at 0°C.

(*b*) The intensity of scattering in four different pieces free from inclusions has been compared and found to be of the same order.

2. The Einstein Smoluchowski's formula, which is based on the principles of statistical mechanics, enables us to calculate the scattering power. Two corrections are however needed: One is due to the known failure of the Law of Equipartition of Energy (Raman's Correction), and the other is due to imperfection of polarisation (Cabannes' Correction). The theoretical value so obtained is 51·2 times that of dust free air and is in close agreement with the experimental value.

3. Several interesting results have been obtained in connection with the scattering in rock-salt.

(*a*) *Imperfection of polarisation.*—When the incident beam is of ordinary unpolarised light, and the scattered light (in a direction normal to it) is examined by means of a double image prism and a Nicol, we get two images of the track, which are brought in a line by properly orienting the double image prism and can be made of equal intensity by rotating the Nicol to either side of its mean position. The mean angle (2θ) between the two positions of the principal planes of the analysing Nicol (when the two tracks are of equal intensity) is about 20° (19–21) and the ratio of the weak component to strong one is given by $\tan^2 \theta = \tan^2 10° = 3\%$ nearly.

(*b*) When the incident light is polarised by means of a Nicol with its shorter diagonal vertical and the scattered light is again examined in a perpendicular direction by means of a double image prism only, the two tracks when in a line are not of the same intensity. On rotating the polarising Nicol on either side of the original position the two images can be brought to equality. The mean angle (a) through which the polarising Nicol has to be rotated from one position of equality to another is about 10°.

When the incident light is polarised as in (*b*) and examined by means of the double image prism, then, as stated above, the two images when in a line or over one another are not of equal intensity, but the equality is obtained, when instead of rotating the analysing Nicol we rotate the double image prism. Four positions of equality are obtained on rotating through an angle of 45° almost from the positions when the two images are in line or over one another. It may, however, be pointed out that if a similarly polarised beam be sent through pure distilled water and the scattered ray be examined as in (c) above, the two tracks (as seen through the double image prism) are of equal intensity when in a line or over one another.

4. Incidentally we are led to think that the rock-salt crystal is also doubly refracting along certain planes. My attention was also drawn to a paper by H. A. Lorentz on the doubly refracting property of rock-salt in certain directions (*vide* Proceedings of Koninklije Akademie Van Wetenschappen te Amsterdem, Vol. XXIV, Nos. 6 and 7, page 332).

Cubic pieces of rock-salt were therefore selected and in each two pairs of parallel faces inclined at 45° to the natural faces were cut and polished; thus in each of these cubes I had one pair of natural faces and two pairs of polished faces.

When one of these pieces is interposed between two crossed Nicols with the new polished faces set normally to the axis of Nicols the light is restored (a property of a doubly refracting crystal).

The polarisation of scattered light has also been studied through such pieces in several ways—

(i) Light incident on a *natural* face and the scattered track examined through a *polished* face.

(ii) Light incident on a *polished* face and the scattered track examined through a *natural* face.

(iii) Light incident on a *polished* face and the scattered track examined through a *polished* face.

Interesting results have been obtained and will be discussed on some other occasion.

The experimental work was carried out by me in the Laboratory of the Indian Association for the Cultivation of Science and I have great pleasure in recording my indebtedness to Prof. C. V. Raman for his continued interest in the research

Induced atmosphere of a monoplane.—*By* N. K. Bose.

According to Praudtl's new conception of air thrust the wings of monoplane are disturbing centres which can be replaced by vortices. The action of the single wing, in the case of a bi-plane, on the other wing is discussed. Firstly, Praudtl's conception is made to suit this new task then we find the superimposed velocity of air current due to this single wing, there comes more technical points of angle of attack, radius of curvature of the stream-lines, lift and circulations change, and finally the change in the drag which this presence brings about. Towards the end Praudtl's conception is broadened and from this more widened outlook the whole problem is surveyed.

"Underblown" Pipes.—*By* A. L. Narayan, G. Subrahmaniam, *and* D. Gunnaiya.

The behaviour of underblown organ pipes presents several interesting peculiarities. The following is a short summary of the results obtained by the authors with four wooden pipes ranging over an octave (256, 320, 384 and 512). The behaviour of the 256 pipe which is the gravest of our set is identical with that described by the late Lord Rayleigh (Phil. Mag. xiii, 1882); that of 320 showed a slight difference, while in the other two the difference became marked at least in one point. In all the pipes a note distinctly lower in pitch as well as in intensity than the fundamental makes its appearance at a few mms. pressure. The minimum pressure to start this note is higher the higher the pitch. This note gets considerably sharper than the fundamental as the pressure rises and ceases at pressures which are also higher for higher pitches. Then in the two lower pipes a note slightly lower than the octave starts a little before or just as the fundamental ceases. In the higher pitches however instead of the octave a period of silence ensues. In fact this octave tone is very feeble even in the 320 pipe and is elicited with difficulty. The periods of silence in the two higher pipes are followed by the normal tones which are, to start with a bit flatter than the fundamental. The pressures at which the normal tones commence are also higher for higher pipes. In the lower pipes the octave tones which started as the underblown fundamentals disappeared, rise with pressure and cease giving rise to normal tones, immediately in the case of 256 pipe and preceded by a very short period of silence in the case of 320. The entire absence of the octave counterpart in the two higher pipes distinguishes their behaviour from the lower ones and that described by Lord Rayleigh. This suggests that the octave counterpart appears for pipes lower than a particular limiting frequency. The difficulty experienced in the case of the 320 pipe also suggests that it is very near the limiting frequency. A fuller account of these investigations will be published shortly.

Rate of ascent of the monsoon air currents in the neighbourhood of Bombay.—*By* S. K. BANERJI.

When wind blows from sea normal to a coast line, a local ascending current is produced on account of the loss in horizontal velocity caused by the increased frictional resistance of the land. An ascending air current will also be associated with winds blowing parallel to a coast line, if the pressure is high over the land and low over the sea, and a descending current with the pressure conditions reversed. The rate of ascent can be calculated in both cases; a quantitative verification of the precipitation, which a particular sample of monsoon currents would cause at the west coast stations, seems therefore possible. This investigation was suggested to me by Dr. Gilbert T. Walker in September, 1922, but we found shortly afterwards that we have been anticipated by Mr. J. S. Dines, who published a paper giving the theory of the effect in the *Quar. Journ. Roy. Met. Society*, October, 1922. It was therefore decided to confine the investigation to a quantitative verification of the actual precipitation. As a preliminary, it seemed desirable to ascertain by observations, the actual rate of ascent of the monsoon currents. For this purpose a balloon was carefully observed when it entered a sheet of nimbus cloud, covering the whole sky, till it became entirely invisible. The vertical velocity of the balloon could be calculated from its height-time curve and therefore its total ascent during the interval it first entered the cloud and finally disappeared. On subtracting from the total ascent of the balloon the distance at which objects ordinarily become invisible in a thick fog, the total ascent of the cloud as well as its rate of ascent could be approximately calculated. The method adopted was to select a number of flights under conditions more or less similar and to form equations of the type.

(Vertical velocity of the baloon from its height-time curve)
× (the time it took to become invisible)
— (distance into the cloud which an object must penetrate to become invisible)
= (Rise of the cloud bodily upwards during the interval).

and then to solve them by the method of least squares. The rate of ascent was found to be much larger than what was given by the equation of continuity formed on the assumption that the monsoon current was blowing over plane land. The larger rate was accounted for as being due to a forced ascension of the monsoon currents caused by the hills (some of which are 1,000 feet high), within a few miles of the Colaba Observatory. Arrangements were also made to observe the movements of isolated patches of nimbus on cumulo-nimbus cloud by two theodolites, one placed at the Colaba Observatory tower and the other at the Castle Time Ball Tower, but satisfactory results could not be obtained for want of suitable conditions for this observation during the last monsoon season.

On a new method of computing the daily rate of standard clocks.—*By* P. C. MAHALANOBIS.

A statistical study, based on actual star observations at the Alipore Observatory.

On the Nature of the Contact E.M.F. of Pure Metals.—*By* S. C. ROY.

The thermionic 'work-function' $\chi_{\text{therm}} = \frac{kb_0}{e}$ volts as computed from the observed emission data according to the law,

$$I = \frac{2\pi mek^2}{h^3} \,.\, (1-r) \,.\, \tau^2 \quad \frac{b_0}{\tau},$$

is compared with the photo-electric 'work-function' $\chi_{\text{phot}} = \frac{h\nu_0}{e}$ volts. It is shown that the 'work-function' is a function of the atomic volume and is calculable absolutely on theoretical grounds. The theoretical values of χ for the various (i) heavy metals, (ii) alkaline earths, and (iii) alkalies; are in remarkable agreement with the computed χ_{therm} and χ_{phot} for these metals in a pure state and under best vacuum conditions. It is concluded, therefore, that 'photo-electrons' and 'thermionically emitted electrons' and as a matter of that 'conduction' electrons are indentical,—thermionic emission in effect being due to photo-electric activity.

Both the intrinsic and the chemical theory of the contact E.M F's of metals are then discussed. Many investigators, of late, have tried to decide between the two theories experimentally and their results appear to favour the chemical theory. None of these experiments can, however, be said to be conclusive, since all their observed phenomena are explicable on the intrinsic theory, when due account is taken of the various actions of the secondary character. The contact P.D. is certainly an intrinsic property of the metals concerned. The chemical theory is only a cloak for our ignorance of the changes caused by the gases and other contaminating agents.

It is also pointed out that experiments alone are sometimes very bad guide to a right decision of the nature of the contact E.M.F. Prof. Millikan's experiments on the alkali metals, for example, lead one to suspect that these metals have the same intrinsic potentials. This arises from the fact that the atomic volumes of these metals being nearly equal, their intrinsic potentials must stand side by side and since these are very much susceptible to contaminations, the small differences may not always be detected owing to the preponderence of the secondary actions. The same remark applies to Prof. Richardson's contention that the contact E.M.F. may be nil under good vacuum conditions. He based his observation on Lester's determinations of the intrinsic potentials of *Mo*, *C*, *Ta* and *W*, from measurements of the cooling effect, leading to a value 4·5 volts nearly same for all these substances. The atomic volumes of these metals are of the same order and it is not unlikely that Lester's determinations failed to detect the small differences. Moreover Lester's calculation of the heat observed per electron is based on the classical theory. But in the light of the present non classical theory, the values should be much less since the 'conduction' electrons contribute nothing to the thermal energy of the metals.

The intrinsic potentials of some metals in volts are given as—*Pt* (4·18), *W* (4·00), *Mo* (3·9), *Ta* (3·8), *Tho* (2·8), *Na* (2·1), *K* (1·9), *Cs* (1·4), *Ca* (3·7), *Ba* (2·9), *C* (4·5).

On the glow of vacuum vessels in the neighbourhood of Induction coils.—*By* D. B. DEODHAR.

It has been observed that the electrodeless vacuum vessels showing Tesla discharges, give a good glow even in the neighbourhood of an ordinary Induction coil. Genisler spectrum tubes also behave in the same way. The glow is maximum when the tube is held in front of one of the secondary terminals; but it fades and totally disappears in the centre of the coil, being again maximum at the other terminal. This is due to the neutralizing effect of positive and negative electric radiations emitted by the two terminals. From this phenomenon it appears that the field due to the electric radiation from an induction coil is sufficient to excite the rarified gas atoms. The vacuum glow shows a banded spectrum when observed spectroscopically. Sharp line spectra as observed in the spectrum tubes when connected to the Induction coil tubes appears as broadened lines when the tube is excited by radiation. A magnetic field produced by a bar magnet is able to deflect the stream of light in the vacuum vessels.

Persymmetric Determinants involving the Integrals of Legendre's Functions.—*By* M. BHIMASENA RAO *and* M. VENKATARAMA AYYAR.

1. The Continued Fraction

$\frac{1}{z+}\,\frac{a_1}{z+}\,\frac{a_2}{z+}\,\frac{a_1}{z+}\cdot\frac{a_2}{z+}\ldots\ldots$ is first shown to be equal to

$$\frac{1}{(b-c)}\left\{(b-c)\frac{1}{z}-\frac{bcP_1-c^2P_0}{2}\cdot\frac{1}{z^3}+\frac{bc^2P_2-c^3P_1}{3}\cdot\frac{1}{z^5}-\frac{bc^3P_3-c^4P_2}{4}\cdot\frac{1}{z^7}+\ldots\ldots\ldots\right\},$$

where the P's are Legendre's functions (of the orders indicated by the suffixes) in $\frac{b}{c}$, b being $=a_1+a_2$ and $c=a_1-a_2$.

2. Hence is obtained the result,

$$\frac{1}{z+}\,\frac{\frac{1}{2}(x+1)}{z+}\,\frac{\frac{1}{2}(x-1)}{z+}\,\frac{\frac{1}{2}(x+1)}{z+}\,\frac{\frac{1}{2}(x-1)}{z+}\ldots\ldots\ldots$$

$$=\frac{1}{x-1}\left\{(xP_0-1)\cdot\frac{1}{z}-\frac{xP_1-P_0}{2}\cdot\frac{1}{z^3}+\frac{xP_2-P_1}{3}\cdot\frac{1}{z^5}-\ldots\ldots+\ldots\ldots\right\},$$

where the ' P 's are now Legendre's Polynomials in x.

3. $$=\frac{I_0}{x-1}\cdot\frac{1}{z}-\frac{I_1}{x-1}\cdot\frac{1}{z^3}+\frac{I_2}{x-1}\cdot\frac{1}{z^5}-\ldots\ldots+\ldots\ldots,$$

where $I_n=\int_1^x P_n dx.$

The authors then proceed to prove that $\frac{I_0}{x-1}$, $\frac{I_1}{x-1}$, $\frac{I_2}{x-1}$, . . occurring above are the co-efficients in the expanded form of the M_0-functions introduced by them and utilize this fact in the evaluation of the persymmetric determinants.

A Statistical Study of the Mysore Age Tables and Indian Age Tables of Census, 1921.—*By* E. R. SOUNDARAJAN.

Introduction—Method adopted for correction and graduation of the Tables—Graphical representation of the same—Calculation of the several statistical constants with their probable errors—Selection of type of curve to be fitted—The best fit is given by type IX: $y=y_0\left(1-\frac{x}{a}\right)^m$.—Comparison with Madras and Bombay Age Tables—Remarks and conclusions.

A Note on the Shift of the Centres of population in select areas of Mysore.—*By* K. B. MADHAVA *and* M. NARAYANA AIYANGAR.

In this paper an investigation is made of two selected tracts in Mysore (comprising mostly of Hassan and Kolar districts) of what is called the "centre of population" which is the same as the Statistical centre of mass of population occupying the areas in question. The centres of population are calculated by the method of moments on the general lines laid down in the report of the United States Census for the distribution as given at the census enumerations of 1871-1921, and while obviously there may be various causes for the migration, an enquiry is started to study the shift with respect to the new railway lines opened in both the areas. Incidentally expressions are obtained also for the areality commanded and the proximity reached between the individuals in those areas.

A Note on the Differential Rates of Mortality between Males in the General Population and Male Insured Officers in Mysore.—*By* K. B. MADHAVA *and* A. V. RAMANATHAN.

(1) The ratios of the rates of mortality at corresponding ages in the several experiences are calculated and studied in detail. Certain prominent characteristics are noticed and accounted for with special reference to climate, economic and other conditions. Factors are classified into positive and negative groups, and a study of the differential co-efficients of the curves suggests the relative importance of the two groups above and the varying forces of action and reaction.

(2) A comparison is made of the survivors according to each experience out of the same number of persons of age 20, at succeeding ages; and graphed.

(3) The complete expectation of life at each age is computed and the mean ages at death of those that die before reaching the age of 55 are also computed and certain interesting inferences are drawn.

An Actuarial analysis of the Mysore Census enumerations of 1921.—*By* K. B. MADHAVA.

It is usual to follow up Census enumerations with an Actuarial analysis to determine the probability of living from age to age and exhibiting the Life Table in full, starting from age zero to the limiting age of the experience investigated. The data required are (1) the correct numbers of the peoples living at their stated ages which should be correct, (2) correct numbers at correct ages of the migrants, (3) correct numbers with reliable ages at death of the deaths recorded, and finally (4) a true and accurate record of births. It has long been known, however, that in Indian Censuses not one of the above criteria is properly obtainable and the Text-Book methods of Actuaries have deplorably failed, but the ingenuity of Sir George Hardy and Sir Thomas Ackland, the Actuaries employed by the Government between 1881 and 1911 has indicated powerful methods to overcome, however imperfectly by mathematical formulae human prejudice born out of ignorance or of wantonness. These methods with suitable modifications to meet the data as available from Mysore Censuses have been employed and Life Tables constructed, one for males and another for females.

The Flourescence Spectrum of Didymium Glass.—*By* N. C. KRISHNA AIYAR.

A Theory of Metallic Viscosity.—*By* DURGADAS BANERJI.

On a method of Comparing Inductance and Capacity.—*By* J. M. GANGULI.

Section of Chemistry.

President :—Dr. E. R. Watson, M.A.

Presidential Address.

I do not propose on this occasion to give you an account of work in any particular field of chemistry or on any special problem or problems. But there are questions of organization, direction and stimulation of chemical research in which we must all be interested to some extent, and it is some of these that I propose to discuss.

When I was a student at Cambridge and just taking up chemical research I felt that it would be a great advantage to beginners if there were available a list, prepared by competent authorities, of chemical researches which it was desirable should be undertaken and which would be likely to lead to results of value and interest. Not exactly for the beginner undertaking his first research This no doubt should be chosen for him by his teacher and carried out under his teacher's supervision and with his advice. There are so many advantages in such a choice of the first research that no other method is likely to be adopted. By this procedure some results are almost certain to be obtained by the application of the experimental methods which the pupil has seen successfully applied by the teacher. Again, the teacher takes an interest in the work as it is of his own choosing and is willing to give his advice at all stages. Again, it helps the teacher to tackle more problems of his own choice than he would be able to attempt if he were confined to working entirely with his own hands. For these reasons a beginner's first research is almost certain to be chosen in this way by his teacher. But it is at the next stage especially that the beginner would be helped by such a list of researches as I have suggested. He probably leaves his teacher's laboratory and goes out into the world to earn his own living. If he has the opportunity of continuing research he must now make his own choice of subject. In many cases no doubt the research he has just completed under his teacher's guidance will have suggested other work more or less in continuation or connection with it, or other subjects connected with the work in progress in the teacher's laboratory will suggest themselves. But at this stage I think it is in most cases desirable to make a break. The teacher probably will not be particularly anxious for the young chemist who has now left his fold to continue with work which is too closely connected with that going on in his own laboratory. He can no longer give it his close attention and it is quite possible that it may overlap the work going on in his laboratory. This line of work was not the young chemist's own free choice and it seems desirable now that he should look round the whole field of chemistry and choose a subject of importance and interest. It seems to me that too many researches now-a-days are of very little interest to anyone. Concerned with some small corner of chemistry, some side issue, they are suggested to the young chemist by some work he has already done or by some unexpected difficulty or unexpected phenomenon in the course of routine work. I say that they are of very little interest to anyone, because I believe that the majority of small papers now published by unknown chemists bear unattractive titles and a casual glance at the summary of results creates little enthusiasm. Owing to the high degree of specialisation we have now reached it is frequently impossible to understand exactly what the research is about without reference to the literature, unless it happens to be on the particular section of chemistry on which one is working oneself. And I think there is a great tendency for the research worker to pass from one such subject to another all through his working days, getting into a groove and specialising in some branch of chemistry which is only of moderate interest to himself and of very little interest to anyone else. I think the research power of the chemical world could be employed to better advantage if it were directed to some extent into definite promising channels by those competent to choose such channels. I think it is important that the young research worker should be very ambitious in the choice of his subject. It is better to attempt an ambitious subject and fail than succeed in a trivial task.

Against my proposal it may be argued that anyone with a good knowledge of chemistry and of the recent advances which have been made in the subject is in a position to prepare for himself a list of researches which now appear desirable and are likely to lead to results of value and interest, so that it should be left to the young research worker to make his own choice. But my contention is that most workers, especially young workers, do not make a very good selection. Perhaps they do not give sufficient thought to the subject in this broad kind of way. But I think the ability to take a broad survey and distinguish the important from the unimportant is essentially a power which is developed in later years. It is generally admitted that judgment comes with age, and this is essentially a matter of judgment. Unfortunately, the power of intense application to laboratory work diminishes with age and we generally find that as a man grows older his output diminishes. His judgment is largely wasted for want of the opportunity of using it. By my proposal we should harness the enthusiasm of youth to the judgment of middle age.

My idea is that a Board of recognised chemical authorities, say, e.g., the professors of chemistry in the British Universities or, perhaps a Board appointed at an International Chemical Congress, should meet once a year and prepare a list of researches which it considers important and urgent and likely to lead to results of value and interest.

Against this proposal it may be urged that a Board is unnecessary. If the preparation of such a list is desirable and would be welcomed it may safely be left to some individual who has the necessary age and judgment and literary tendencies. I know only of one author who has made any suggestions in this direction. I refer to a chapter in Stewart's Recent Advances in Organic Chemistry. But whilst I think such lists prepared by individuals would be far better than nothing and be heartily welcomed, it is obvious they could not be free from individual bias and would not be so comprehensive or so well proportioned as a list prepared by a Board.

Another objection to my proposal is that if anyone has ideas for research which he considers valuable he is going to keep them for himself and his pupils. It is difficult enough, he will say, to find suitable subjects for himself and his pupils. In fact the choice of such subjects is one of the most difficult and important tasks of the professor or director of research. Even if he had a superabundance of ideas, more than he could possibly use himself, he would not be satisfied that the best had been made of them by anyone working without his supervision and advice. My answer to this is that if such an individual found himself on my suggested Board he need not communicate to the Board any such ideas as he considers likely to have occurred to himself only. He would probably be able to suggest subjects in other branches of chemistry in which he is not so personally interested. In fact it is unlikely that any subject would be listed by the Board which had not been suggested by several members in the same year.

Another objection to my proposal is that it is only busybodies and people who are fonder of talking and advising other people than of working themselves who would consent to sit on such a Board. The men who are really keen and competent research workers would be too busy with their own work, and the effect of such a Board would be to give the organisation and control of research into the hands of mediocrities and self-seekers, men who are out to make a name for themselves by the work of others. This might happen if the Board were given administrative control of the whole research work of the world or the British Isles, as the case might be, if they could allot definite problems to definite individuals and say you can tackle this problem or these problems and these only, and no one else is permitted to touch them now they have been allotted to you. But such administrative control is obviously unthinkable, and I cannot see that the suggestions of my Board would hamper anyone or that the credit for researches suggested by the Board would go to the Board rather than to the individuals who carried out the researches.

Another idea which I formed at Cambridge has remained with me ever since. Dr Ruhemann, my teacher, used to discuss with me the work he had on hand with his theories as to what should happen in the experiments he was about to perform. It was chiefly a question of attractions and repulsions between negative and positive groups, sometimes modified by steric hindrance I found these discussions very interesting but when the papers were written they were merely a statement of experimental results and said nothing about the expectations with which the work was started and how far these expectations had or had not been realised. As Dr. Ruhemann explained, the experimental facts were definitely established whilst the theories which had led to the experimental work were only tentative working hypotheses and he would not care to put them forward in a formal paper. The Publication Committee of the Chemical Society seem to adopt the same attitude. I know they are very pressed for space and have to ask authors to curtail their papers as much as possible and introductory remarks can be sacrificed without omitting any of the actual results of the research. But if every author were invited to state the reasons which led to his research and what results he hoped to get I venture to think it would make many papers much more interesting. It would of course reveal the bareness of the land if the investigator had no particular purpose in view. This in its turn would undoubtedly serve a useful purpose in making an investigator marshal his reasons before undertaking a research. You will see that here again I am complaining that the chemical journals are not very readable. The fault may lie in myself: I know chemists who read their chemical journals with interest and avidity. Personally, I find little pleasure or profit in reading the current numbers of the chemical journals in an easy chair. If I have the time and the energy to sit up at a desk and consult references and make notes I can find more interest in the papers. But how many of us regularly have the time and energy for this? Would it not be better to recognise that most of us would like the papers to be readable in an easy chair? I have the same complaint to make about the annual reports on the progress of chemistry. I know the various sections differ considerably in style and in treatment and some authors of sections have done a good deal in concentrating on what they consider the leading work of the year and showing its importance and interest. But generally speaking I find it difficult to read the annual reports without sitting up at a desk, consulting references and making notes.

whilst here again I should like to be able to read them in an easy chair after dinner or on a railway journey. I may go further and complain how few books there are on the progress of chemistry or on any branch of chemistry which are readable with interest under such conditions. There was one book which made a great impression on me. That was Lachmann's Spirit of Organic Chemistry which is now out of print and unobtainable. That book filled me with exceptional enthusiasm and interest for organic chemistry. The chapters of chemistry recounted read like fairy tales. They described how the work of the investigator opened up the mysteries of Nature which became ever more complicated and mysterious as the work progressed. I was filled with a great desire to take a part in this fascinating work. But I have come across no other books like it in this respect. Yet the literary style of this book was not particularly good. I remember several examples of mixed metaphor in it. But it was a tale of human interest. It showed the curiosity of the investigators, their expectation and enthusiasm, how the results obtained often exceeded the bounds of expectation and revealed fresh wonders at every step. I have often wondered whether it is possible to make chemistry as interesting to the casual reader as an ordinary novel. There will no doubt be members of my audience who will say why should we wish to make chemistry interesting to the lazy reader. If anyone will take the trouble to study the subject seriously and strenuously he will find himself amply repaid and the subject full of interest. But I am afraid most of us have little time to study the whole of chemistry and cognate subjects in this strenuous way. Most of us have routine work to do and in addition have tied ourselves down to some experimental investigation in a specialised branch, and these two together take the best of our energy and leave us little for other subjects. So that whatever our inclination, circumstances reduce us to the condition of casual readers of the other branches of chemistry and other sciences. It seems at first curious that novels should be so interesting. They only deal with the lives of imaginary individuals and yet they are more interesting to most of us than the lives of real persons whom we know and some of whom may affect our own lives. There is no doubt a good deal in the fact that the figures move more rapidly and years, or it may be a life-time, are condensed into a few pages; again the motives, aspirations and strivings are revealed to us, whilst in real life we see the actions but are left to guess the motives. I think to most of us a novel is interesting in proportion as the characters are real and act as we might expect human beings to act. Novels fail if the characters seem wooden or doll-like, and to most of us highly imaginary novels concerned with the inhabitants of the moon and the like fail to interest deeply. If these are real reasons why novels are more interesting than chemistry books, it follows that we could make chemistry more interesting by retaining the human element describing the ideas, hopes, aspirations and strivings of the investigator and how far his labours were rewarded with success, how far his ideas were modified as the work progressed. But I think there are other factors to be considered. Last hot weather I went on a railway journey and took with me some chemistry books and a book—I have forgotten its title and author—giving the writer's impressions of a number of contemporaries, politicians, writers, musicians, artists and the like. I had no initial interest in most of these personages, having never heard of most of them, yet I could read this book with interest whilst the chemistry books sent me to sleep or at any rate failed to prevent me from falling asleep. It struck me then that it was probably a matter of presentation. The chemistry books were written by chemists who had probably paid little attention to the art of writing, whilst the other book was written by a man who made literature his profession and studied how to make his sentences harmonious and elegant and how to bring out the salient features and make his characters picturesque, to give light and shade and delicately drawn little bits of detail in his sketch—in fact he had studied how to make his writing interesting to the ordinary reader. I feel that if our papers, reports and text-books were written more on these lines, if more attention were paid to the human element in scientific investigations and more care devoted to the presentation of the subject, bringing out the wonder and the elusiveness of Nature, the extra labour would be well worth while. Of course here we are up against a difficulty—the scientific investigator has not spent a lifetime in studying how to write and the literary man has not spent a lifetime in studying the history and results of chemical science. Still I think much might be done if the ordinary scientific worker were allowed more space to describe the motives prompting his work and were encouraged to give more attention to literary style; and if some of the older men who have given up laboratory work and taken to writing would devote more attention to literary style. I think also it would be worth while if, say, the Chemical Society would produce a decennial report, having it written by a literary man in collaboration with chemists.

Of recent years I have given a good deal of my time to applied chemistry. I have wished to produce something of some obvious use. I have tried to produce new dyes which would find practical application. Some of the dyes which I produced were criticised by manufacturers on the grounds that the raw materials or the processes of manufacture were too expensive, or the shades of colour produced were not much in demand, or the dyes had not sufficient fastness to light, washing, perspiration or the like. If these criticisms were sound I could have been saved a good deal of labour by having my ideas criticised by manufacturers before I started to work on them. Of course, the ordinary manufacturer, like most other people, is conservative and might criticise adversely a very good idea. Nevertheless, I feel that more contact with the manufacturer would be of great benefit to the research chemist who is anxious to produce new products of practical utility. It is of course now possible for a certain number of research chemists to find employment by manufacturers and it may be taken for granted that their researches are of practical utility, otherwise they would not be employed. But I do not know whether such work gives complete satisfaction to the research chemists. It may be a matter of temperament. Such work may give complete satisfaction to some and not to others. Generally the chemist will be required to forego the pleasure and satisfaction of publishing the results of his investigations. His salary and the feeling that his work is of practical value generally will be his rewards. Frequently the work will not count for much as an addition to chemical knowledge. It is useful to his employer as the solution of a special problem depending on local conditions, ruling prices and so on. This brings me to a comparison of applied and pure chemical research on which I have thought a good deal and feel I should like to say a few words. The disadvantages of the research chemist working for a manufacturer I have just outlined. In most cases he will have to forego the pleasure of publishing the results of his researches, and for a man who is anxious to make a name in the chemical world this is a great deal. But suppose this privilege is not withheld from the applied research chemist, will his work give him the same satisfaction and reputation as if he devoted his energies to pure chemical research? May I take my own experience during the last four years as an example? In 1920 I read a paper to the Indian Science Congress on Chemical Research for the Development of Industries in India and since then I have spent a good deal of time working and directing the work of my assistants on the lines suggested in that paper, but especially with reference to the development of industries in the U.P. We have given facts and figures for holding the view that the alkaline deposits of the U.P. could profitably be used for the manufacture of soda ash, caustic soda, sulphuric acid and sodium sulphide. We have shown that Portland Cement of good quality can be manufactured from materials available in the U.P. and these materials are sufficiently cheap and plentiful to make the manufacture of this material in the province a likely proposition. We have worked out a process for the refining of neem oil which may render available a considerable quantity of another oil for soap-making and perhaps for edible purposes. We have shown that the bark and wood of the Himalayan oak (*quercus incana*) may provide a suitable material for the manufacture of tannin extract. We have shown that T.N.T. and other derivatives of aromatic hydrocarbons can be obtained from Assam and Burma petroleum.

It is obvious that these views do not rest entirely on chemical facts. Economic considerations had also to be taken into consideration to arrive at them. If this work leads to the industrial utilisation of raw materials available in the U.P. it will be a source of considerable satisfaction to us. It may be a source of profit if certain patented processes find practical application.

But whether these processes will or will not find practical application obviously does not depend entirely on the results of these investigations. Economic and other considerations will determine whether anyone will come forward to work these processes.

But as chemistry there is very little interest in these results and they can therefore do little to increase the reputation of the investigators in the chemical world.

This is a danger against which I would like to utter a word of warning to anyone who is thinking of taking up research in applied chemistry. If you are at all ambitious as a chemist, if you wish to make a name in the chemical world, you must see that you choose problems the solution of which will constitute a distinct contribution to chemical knowledge and you must see that you take a sufficiently broad view of applied chemistry and tackle problems which are of more than local interest. You are almost sure to find problems which are locally of considerable economic interest, problems which local manufacturers and business men would like you to investigate because your investigations may show the possibility of starting paying factories. The more conscientious you are and the more anxious you are that your work should be of practical value, the more likely you are to be led into these enquiries which are of local rather than general chemical interest. But if your own interests and ambitions lie in the chemical world you cannot afford to confine yourself to these problems which are only of local economic interest. You must choose problems the solution of which will constitute some distinct advance in chemical knowledge. There are plenty of such. Some of the most popular achievements of chemistry have been the solution of such problems, e.g., the synthesis of indigo, the manufacture of synthetic colouring matters generally, the discovery of salvarsan and the synthesis of ammonia from atmospheric nitrogen.

To summarise rather a rambling discourse, I have suggested the desirability of—

(1) A Board of recognised chemical authorities to prepare an annual list of chemical researches which are urgently required and likely to lead to results of value and interest.

(2) Allowing scientific workers more space in the journals to describe the motives prompting their work and encouraging them to give more attention to literary style.

(3) More attention being given to literary style and mode of presentation in papers, reports, books and all publications dealing with chemistry.

(4) More contact between manufacturers and chemists anxious to take up problems of applied chemistry.

(5) The worker in applied chemistry seeing that the problems he undertakes are not merely of interest to local manufacturers but that their solution would constitute some distinct advance in chemical knowledge.

Some derivatives of *p*-methoxycinnamic acid.—*By* J. J. SUDBOROUGH *and* K. V. HARIHARAN.

Appreciable amounts of ethyl *p*-methoxycinnamate can be obtained from the tubers of *Kaempheria Galanga.* From this ester the free acid, the acid dibromide and the ester dibromide have been prepared, and the action of alcoholic potash on the dibromo-compounds has been studied. The elimination of hydrogen bromide from the acid dibromide is accompanied by the liberation of appreciable quantities of carbon dioxide and the main product is a *p*-methoxy-bromocinnamene, but small amounts of a *p*-methoxy-β-bromocinnamic acid melting at 121–123° are also formed.

By the action of alcoholic potash on the ester dibromide good yields of an isomeric *p*-methoxy-*a*-bromocinnamic acid melting at 182–184° are obtained. The ethyl ester of this acid boils at 168–170° under 5 mm. pressure, and yields a tribromide, $CH_3O \,.\, C_6H_4 \,.\, CHBr \,.\, CBr_2 \,.\, CO_2C_2H_5$, melting at 109–110°.

The Relation between the Iodine Values and Refractive Indices of hardened Oils, Part II.—*By* J. J. SUDBOROUGH *and* H. E. WATSON.

The relation between the iodine value and refractive index has been determined for the following oils:—

Olive, poppy seed, seal, cashew nut, rayan (*Mimusops hexandra*) soya bean, palm, cod liver, neem, rape, rocket and mustard.

In all cases the oils were refined with alkali before use. Rocket oil contains a powerful catalyst poison which was removed by extraction with alcohol.

The curves representing the relation between iodine value and refractive index for all the oils are similar in shape and very nearly parallel. Those for the first six oils mentioned lie close together and the refractive indices for the completely hardened oils are within the limits 1·4461 and 1·4466 at 60°. This figure is rather lower in the case of palm oil (1·4456) slightly higher for cod liver and neem oils (1·4474 and 1·4470 respectively) and higher still for the rape oil group (1·4481 to 1·4490). These figures agree fairly closely with those which may be calculated from a knowledge of the constituents of the oils.

Oil from the Seeds of Mimusops Hexandra.—*By* C. K. PATEL.

An examination has been made of Rayan Oil obtained from the seeds of *Mimusops hexandra*. Roxb., both by expression in a ghany and by extraction with ether. By expression a 17·5 per cent yield of oil is obtained and by extraction 24·6 per cent, or calculated on the weight of kernels 47·2 per cent.

The oil closely resembles mohua and cashew kernel oils and has an iodine value of 65 per cent and when kept for some time it deposits a solid stearin. It is readily refined by alkali treatment. It is then obtained as a very pale yellow liquid with an odour resembling olive oil and is equal to refined gingelly oil for edible purposes. It is readily hydrolised by castor seed lipase.

The refractive index iodine value curve resembles those obtained for cotton seed and mohua oils.

The seeds contain a bitter principle soluble in water or 90 per cent alcohol. This principle is not precipitated by basic lead acetate and is insoluble in chloroform.

Kachi Grass Oil.—*By* B. SANJIVA RAO.

This oil obtained by steam distillation from the flower heads of species of *Cymbopogon*, common in South India, has the composition of a ginger grass oil and contains *d-* or *l*-limonene, dipentene, geraniol, and *d-* or *l*-perillic alcohol. The yield is about 1·6 per cent calculated on the dry flower heads. The percentage of terpenes appears to decrease as the flowers mature and the oil becomes more soluble in 70 per cent (by volume) alcohol.

It is possible to render so-called insoluble oils soluble in 70 per cent alcohol by removal of a portion of the low boiling constituents. On standing a change occurs in the following physical constants of the oil: refractive index, optical rotation and solubility.

Finely-divided Copper as a Catalyst.—*By* R. C. SHAH.

It is well known that finely-divided copper (Natur Kupfer C) can be used for bringing about condensations between halogenated benzene derivatives and primary or secondary amines or phenols at relatively high temperatures.

It is now shown that at comparatively low temperatures the same reagent can be used for condensing halogenated aliphatic compounds with aniline or diphenylamine. Thus aniline and carbon tetrachloride yield diphenylaminobenzamidine (50 per cent yield) and a second compound $C_{19}H_{17}N_3$ (12 per cent yield) melting at 115°. This latter compound when hydrolysed with a mixture of acetic and hydrochloric acids yields a product, $C_{15}H_{12}ON_2$, melting at 143°.

Chloroform and diphenylamine yield triphenylparaleucaniline (12–15 per cent yield), and bromoform and aniline yield paraleucaniline (4 per cent) and pararosaniline (6–7 per cent).

Iodine as a catalyst in condensations involving the elimination of hydrogen chloride.—*By* R. D. DESAI.

Knoevenagel has shown that iodine has a pronounced catalytic effect on certain condensations in which water, ammonia or hydrogen sulphide is eliminated and Hibbert has also found the reagent an efficient catalyst in the preparation of unsaturated hydrocarbons (or ketones) by the elimination of water from the corresponding hydroxy saturated compounds.

The author shows that the same reagent can be used as a catalyst in condensations accompanied by the elimination of hydrogen chloride.

The reactions so far studied have been the production of mono- and di-benzylaniline from aniline and benzyl chloride and diphenyl benzylamine from diphenylamine and benzyl chloride; also the formation of diphenylamine blue (10 per cent yield) from diphenylamine and carbon tetrachloride.

Studies on the relation between optical activity and chemical constitution. Part V. Derivatives of *d*-camphorimide and *d*-camphoramic acid.—*By* B. K. SINGH *and* A. C. BISWAS.

The molecular rotatory powers and rotatory dispersions for sodium yellow, mercury yellow, and mercury green lines in six solvents of the following derivatives of *d* camphorimide and *d*-camphoramic acid are investigated: *d*-camphorimide, *d*-camphorbenzylimide, *d*-camphor-nitrobenzylimide (*ortho*, *meta*, and *para*); benzyl-*d*-camphoramic acid and *m*-nitrobenzyl-*d*-camphoramic acid.

Most of the derivatives are new substances.

The following conclusions can be drawn from this work:—

(1) The effect of substituting a hydrogen atom by a heavier radical is to increase the rotatory power, except in the case of *m*-nitrobenzyl group in methyl alcohol solution.

(2) The effect of the solvent on the rotatory power is variable. The molecular rotation of *d*-camphor-*o*-nitrobenzylimide is more than five times in methyl alcohol than in ethyl alcohol, whereas in the case of the *meta*-compound, this is more than four times in ethyl alcohol than in methyl alcohol.

(3) The rotatory power of *d*-camphorimide and derivatives is very low in benzene solution, except in the case of *o*-nitrobenzyl derivatives. When the ring is broken, as in the case of camphoramic acid derivatives, this abnormality disappears.

(4) The order of position isomerides on the rotatory power is altered with the nature of the solvent. Frankland's rule is not followed, but Cohen's rule is.

(5) The effect of the ring structure is to diminish the rotatory power.

(6) An analysis of the rotatory dispersion values of *d*-camphorimide and derivatives shows that it is high in benzene solution, except in the case of *d*-camphor-*o*-nitrobenzylimide. This finds a remarkable parallel in the rotatory power of these compounds, which is low in benzene (see '3' above).

(7) The *o*-, *m*-, and *p*-nitrobenzyl-*d*-camphoramic acids exist in two forms, distinguished by their melting points or colour.

Chemical changes in sunlight.—*By* R. P. SANYAL, R. C. BANERJI *and* N. R. DHAR.

Many chemical changes which were believed to take place only in ultraviolet light have now been induced in sunlight containing no wavelength smaller than 290 $\mu\mu$. Formation of:—

(1) Formaldehyde and reducing sugars from carbon dioxide and water.

(2) Sulphur trioxide from gaseous sulphur dioxide and oxygen gas at the ordinary temperature.

(3) Nitrite from nitrate solutions at the ordinary temperature.
(4) Iodine from solid iodic acid.
(5) Potassium chloride from potassium chlorate solution.
(6) Reducing sugar, formaldehyde and carbon dioxide from acetone.
(7) Nitrite from ammonia and oxygen.
(8) Methylamine from ammonia, carbon dioxide and formaldehyde.
(9) Nitrogen from ammonia and oxygen gas.
(10) Decomposition of sugars into carbon monoxide, hydrogen, methane, ethane, traces of formaldehyde, etc.

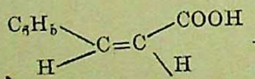
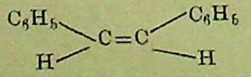
The temperature of explosion for endothermic substances. Additive Compounds of trinitroresorcinol and their temperature of explosion.—*By* R. L. DATTA *and* S. K. BANERJEE.

Additive compounds of trinitroresorcinol and the following substances have been prepared and their temperatures of explosion determined :—

Anthracene, 413·5°C ; β-Methylnaphthalene, 411·5°C; phenanthrene, 405·5°C ; α-Methylnaphthalene, 399·5°C ; Fluorene, 315·5°C ; naphthalene, 312·5°C ; acenaphthene, 261°C ; α-naphthol, 288·5°C ; β-naphthol, 252°C ; β-naphthylamine, 373·5°C ; piperidine, 305·5°C ; ψ-cumidine, 289·5°C ; propylenediamine, 288°C ; pyridine, 286·5°C ; diethylamine, 279°C ; α-naphthylamine, 272°C ; *m*-Toluidine, 263°C ; aniline, 249°C ; *o*-Toluidine, 248°C ; dimethylnaphthylamine, 239·5°C ; hexamethylenetetramine, 474·5°C ; guanidine, 414·5°C ; *p*-chloroaniline, 338·5°C ; dimethylpyrone, 329·5°C ; *p*-bromaniline, 33·5°0C ; acetamidine, 285·5°C ; p-parazine, 270°C ; 1-nitro-2-naphthylamine, 269°C ; *o*-anisidine, 239°C.

Chemical reaction in polarised light—Synthesis of optically active varieties of asymmetric compounds.—*By* J. C. GHOSH *and* R. M. PURKAYASTHA.

It is well known that when an asymmetric compound is prepared in the laboratory, the *dextro* and *laevo* varieties are produced in exactly equal quantities, with the result that the compound does not show any rotation of the plane of polarisation. In the following photo-chemical reactions, it was found that if ordinary light be used as the synthesising agent, the substances produced are optically inactive, whereas, if circularly polarised light be used for photosynthesis, one of the optically active varieties preponderates :—

	Reaching substances.	Solvent.	Length of tube.	Observed angle of rotation.
(1)	 + Br_2	absolute alcohol	10 cm.	−0·14°
	,,	,,	20 cm.	−0·27°
(2)	 + Br_2	CCl_4	10 cm.	+0·15°

The dibromides produced are stable in both cases, and the error of observation in the polarimeter can never exceed 0·05°.

Dyes derived from acenaphthenequinone.—*By* A. C. SIRCAR *and* S. K. GUHA.

The communication deals with the preparation and properties of azine and azonium dyes obtained from ε-acenaphthenequinone and its 3 : 4-dinitro derivative. The object of the investigation was to find out if such bodies possessed sufficiently developed tinctorial properties to be used as dyes like the corresponding phenanthraquinone derivatives. The following compounds and their dyeing properties have been described :—acenaphtha-tolazine, acenaphtha-naphthazine, 3 : 4 dinitro-acenaphtha phenazine, 3 : 4-dinitro-acenaphtha-naphthazine, 3 : 4 dinitro-acenaphtha-phenazinazine, acenaphtha-naphthazine-5′-sulphonic acid, 3 : 4-dinitro-acenaphtha-naphthazine-5′-sulphonic acid, phenyl-acenaphtha-naphthazonium chloride, naphthyl-acenaphtha-phenazonium chloride, phenyl 3 : 4 dinitro-acenaphtha-naphthazonium chloride, 3 : 4 dinitro-acenaphtha-tolazine, 3 : 4-diamino-7 : 12-dihydro-acenaphtha-phenazine, 3 : 4-diamino-7 : 12-dihydro acenaphtha-naphthazine, and 3 : 4-dihydroxy-7 : 12-dihydro-acenaphtha-phenazine.

The influence of multiple chromophores on the colour of Azine dyes.—*By* A. C. SIRCAR *and* P. C. DUTT.

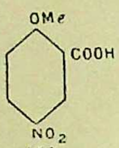
The communication gives an account of the work which was done with the object of finding out the influence of the introduction of additional heterocyclic azine ring on the colour of the simpler mono-azines. A number of phenanthraphenazinazine derivatives have been prepared and their colours compared with those of the corresponding mono-azine derivatives, and it has been shown that the colours of the mono-azine dyes can be easily and appreciably deepened by the introduction of an additional chromophoric group.

Studies in the Isatin series.—*By* A. C. SIRCAR *and* A. K. GUHA.

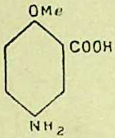
Notwithstanding the readiness with which isatin and its substituted derivatives condense with *o*-phenylene-diamine to yield indo-phenazines, no attempt had hitherto been made to utilise isatin for the preparation of technically valuable azine dyes. The indo-phenazines are, owing to the lightness of their colour, scarcely of any interest from the dyers' point of view. The present investigation was undertaken with the object of preparing from isatin azine dyes, possessing well-developed tinctorial properties, in the same way as had been done in the phenanthraquinone series (Watson and Dutt, J.C.S., 1921, J-1211 ; Sircar and Dutt, J.C.S., 1922, J-1952, etc.), and the communication deals with the preparation and study of the dyeing properties of a number of (*a*) indo-naphthazines obtained by condensing 1 : 2-naphthalene-diamine with various isatin derivatives, (*b*) indo-amino-phenazines, containing the amino group in the benzenoid part of the molecule, and (*c*) indo-azines obtained from some new derivatives of isatin that have been prepared during the course of the investigation. It has further been shown, for the first time, that it is possible to prepare azonium derivatives from isatin by first fixing the labile imino-hydrogen atom by alkylation and then condensing the N alkylated-isatin with any mono-alkyl-ortho-diamine, in presence of hydrochloric acid.

The synthesis of 5-hydroxy 2-methoxy benzoic acid.—*By* A. N. MELDRUM *and* M. S. SHAH.

In connection with work on sulpho-salicylic acid the authors prepared 5-hydroxy 2-methoxy benzoic acid, because this substance might be one of the products when the methyl ether of sulpho-salicylic acid is fused with potassium hydroxide.



(I)



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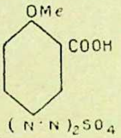

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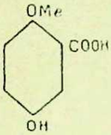


(IV)

5-nitro 2-methoxy benzoic acid (I) having been prepared, was reduced to the corresponding amino-compound (II). Treatment of the amino-sulphate with nitrous acid gave a diazo-sulphate (III) which resisted decomposition by heat. Finally a solution of it was mixed with fused magnesium-chloride at about 145°–155°, and the product was 5-hydroxy 2-methoxy benzoic acid (m.p. 172°) (IV).

Fischer and Pfeffer (Ann., 1912, *389*, 198) have described the preparation of 5-hydroxy 2-methoxy benzoic acid, starting from 2:5-dihydroxy benzoic acid (gentisic acid). The melting point of their substance was 155°–156°, and the substance gave a colouration with ferric chloride.

The authors found that their substance (m.p. 172°) gave a colouration with ferric chloride: they converted it by methylation into 2:5-dimethoxy benzoic acid which melted at 80°. Tiemann and Müller (Ber., 1881, 14, 1993) found that this substance melts at 76°.

Preliminary Note: Properties of the group -$CHOH\text{-}CCl_3$.—*By* R. L. ALIMCHANDI *and* A. N. MELDRUM.

The authors have observed, in the case of various substances which contain the group -$CHOH\text{-}CCl_3$, that this group can be converted into -$CH_2.CHCl_2$. The reagent is zinc dust in the presence of acetic acid. The change takes place with ease and does not readily proceed further. (See T. 1921, *119*, 204.)

The authors are investigating this reaction in the case of aromatic and fatty compounds, with a view to using substances that contain the group -$CH_2.CHCl_2$ for synthetic purposes.

Condensation of aromatic aldehydes with nitromethane.—*By* M. G. SRINIVASA RAO *and* C. SRIKANTIAH.

The following aldehydes have been used for condensation:—(1) Vanillin, (2) 4-methoxy, β-resorcylic aldehyde, and (3) 2:4-di-methoxy benzaldehyde.

1—has been condensed by Knoevenagel (Ber., 1904, 37; 4502, 8); while studying the properties of the condensation product we noticed that it could function as an indicator. It appears to be valuable for colorimetric estimation of H-ion concn., between $P_H = 7\text{–}8{\cdot}5$ and $P_H = 10\text{–}11{\cdot}5$, especially for the latter range. In alkalimetry it compares favourably with phenolphthalein and methyl red. The colour changes vary from pale yellow in acids to violet red in alkalies.

2—did not give the desired condensation product; work is being continued.

3—readily condensed (with methyl amine as condensing agent) and gave bright yellow needles, which have a feeble greenish yellow fluorescence (m.p. 104°). The properties of this compound and that of vanillin are being studied.

Substitution in resorcinol derivatives.—*By* M. G. Srinivasa Rao *and* M. Sesha Iyengar.

Some resorcinol derivatives have been nitrated with a view to examine the position taken by a nitro group.

4-methoxy, β-resorcylic aldehyde, was the starting point for this work. This was isolated from certain roots and its constitution was established (Perf. and Essent. Oil Rec., Aug. 1923, 300). From this a nitro-aldehyde, (I) was obtained under differing conditions. After purification this melted at 168–9°. This nitro aldehyde was oxidised to an acid (II), by permanganate, and was shown to be identical with the acid we prepared by nitrating *p*-methoxy salicylic acid. M.P. of this nitro acid 223-8° (decompn.). The constitution of this acid was proved and it was shown that the nitro group was in 5-position, by heating it in a sealed tube for 4 hours at 160°, when 4-nitro resorcinol-3-methyl ether was obtained, melting between 139-144°. (See Perkin, Robinson, Harding, Salway, Simonsen, etc., J.C.S. Trans., 1902, 1911, 1909 and 1917, etc., in connexion with nitration.) The nitro aldehyde, (I), was methylated and was found to be identical with the nitro aldehyde we obtained by nitrating 2-4° dimethoxy benzaldehyde, with a M.P., 188-9°, and this clearly shows that the nitro group in the dimethyl ether also has taken the position -5. Thus it shows that the mono- and dimethyl ethers of β resorcylic aldehyde orient the nitro group into -5 position, as also the 4-methoxy acid, (II).

On Nitrophenols.—*By* S. M. Sane *and* S. S. Joshi.

Di- and trinitro-phenols react with toluene-sulphonchloride with the formation of di- or trinitro-chlorobenzene or di- or trinitro-phenoltoluene-sulphonic acid-esters. The behaviour of other nitrated chloro- or bromo phenols is examined.

On Embelic acid.—*By* S. M. Sane *and* P. I. Asthana.

Embelic acid is found in the dried fruit of *Embelia ribes* which is used in India for tapeworm. The extraction of embelic acid and some of its derivatives are described.

Adsorption of Acids by Silica in its Relation to the latent Acidity of sour soils.—*By* J. N. Mukherjee *and* K. C. Bhattacharya.

Sour soil has been synthesised with carefully washed pure precipitated silica and the following acids: hydrochloric, nitric, acetic and sulphuric acids. Pure precipitated silica adsorbs acids which cannot be removed by simple washing with water. But on shaking with a neutral salt solution, e.g. solution of potassium chloride appreciable quantities of acids are liberated. If the silica has not been treated with acids no acids are liberated on shaking with a solution of potassium chloride.

Aluminium and ferric hydroxides do not show a similar behaviour.

Electro endosmotic experiments show that anions only are adsorped by silica, i.e. the molecules are not adsorbed as such.

Methyl orange has been used as an indicator to test the acidity of the extracts.

The different explanations advanced to account for latent acidity have been discussed in the light of these experiments.

The Influence of anions on the coagulation of arsenious, sulphide and gold hydrosols.—*By* J. N. MUKHERJEE *and* S. G. CHAUDHURI.

Equicoagulating concentrations have been compared by a new method free from some common sources of error. It has been shown that the anion effect is very small so long as the anions are nitrate, chloride, bromide and iodide or sulphate; the catian concentration is independent of these anions.

There is no relation between valency of the anion and the stabilising effect that it exerts.

The very frequently observed effect of the valency of anion and its adsorbability (as deduced from coagulation and 'electro kinetic' experiments) is entirely absent when the ion and the colloid surface are similarly charged The valency effect became prominent only when the ion has a charge opposite in sign to that of the colloid.

Experiments on the reversal of the charge of colloidal surfaces and the preparation of stable suspensoids with a charge opposite in sign to that usually obtained.—*By* J. N. MUKHERJEE *and* B. C. ROY.

Electro-endosmotic and cataphoretic experiments on the charge of mercuric, cupric and arsenious sulphides; of sulphur and gamboge confirm the views advanced by Mukherjee to account for the reversal of the charge of surfaces brought about by electrolytes.

Experiments on the rate of coagulation of arsenious sulphide sols in the light of Smoluchowski's theory regarding the kinetics of coagulation.—*By* J. N. MUKHERJEE *and* S. K. MAZUMDAR.

The results confirm Smoluchowski's assumption of a constant rate of coalescence as defined by him. In the region of what is commonly called "slow coagulation" the limiting stage of coalescence is reached depending on the rate of coalescence. The more advanced the limiting stage becomes the greater the rate of coagulation. During the initial stages Smoluchowski's relation holds but it fails beyond a certain stage.

The experiments leave no doubt that the irreversible coalescence of these sols at high concentrations of electrolyte became completely reversible at lower concentrations. This reversibility of the coagulation has not been recognised previously.

A new interpretation of the Schulze-Hardy Law and the importance of adsorption in the charge reversal of colloids.—*By* N. R. DHAR, K. C. SEN *and* S. GHOSH.

1. From a survey of the experimental results on coagulation and adsorption it is found that an ion which has a high precipitation value (a small coagulative power) for a colloid is most adsorbed by the colloid. Inversely the smaller the precipitation value (that is, the greater the coagulative power), the less is the adsorption. This is the proper explanation of the so-called Schulze-Hardy Law. The above generalisation is supported by the actual experimental results of various workers.

2. On the addition of an electrolyte to a sol the first step is the neutralisation of the electric charge on the colloid particles, by the adsorption of ions carrying a charge opposite to that of the sol. The second step is the further adsorption of the electrolyte by the neutral

particles. It is only for the first step that the Schulze-Hardy Law is applicable.

3. A suggestion based on kinetic and adsorption points of view, explaining the existence of a minimal concentration of electrolytes for the coagulation of colloids has been advanced.

4. Charge reversal depends essentially on the amount as well as on the permanency of adsorption. Ions such as hydrogen, hydroxyl, etc., which are more or less permanently adsorbed in large quantities are most active in charge reversal.

5. Substances which are neither strongly acidic nor strongly basic, are capable of adsorbing positive or negative ions and pass into the colloidal state. Charge reversal with these cases are also very frequent.

6. It appears that charge reversal is possible in those colloids where the neutralised particles of the sol can immediately adsorb more of the precipitating ion.

7. We are of opinion that charge reversal, amount of adsorption and complex formation go hand in hand and depend on the chemical affinity existing between the adsorbent and the substance which is being adsorbed.

8. Recent experimental work on the adsorption from salt solution of the basic portion by silica, cupric hydroxide, manganese dioxide, etc., proves that soil acidity is very likely due to the adsorption from salts of the basic portion by silica, humic acid, etc., present in the soil.

On adsorption and peptisation.—*By* K. C. SEN.

The author has studied the formation of colloids from the adsorption point of view. There are several methods of peptising an insoluble precipitate and in the present paper an investigation has been made of the effect of different acids on hydrated oxides, specially, hydrated ferric oxide. It has been observed that hydrated ferric oxide is a good adsorbent of acids and a connection has been traced between adsorption and colloid formation. It has been found that in general adsorption of one ion takes place which then makes the hydroxide pass into a sol. Various acids such as hydrochloric, nitric, sulphuric, acetic, salicylic, benzoic, oxalic, boric, arsenious, meconic, malic, tartaric, molybdic, etc., have been used and it has been found that the resulting colloid has either a positive or negative electrical charge depending on the nature of the acid used. Thus in the case of hydrochloric or acetic acid, the colloid is positively charged, whilst in the case of arsenious acid the colloid is negatively charged. Incidentally the formation of basic salts, the peptisation of hydroxides by the respective metallic salt solutions, and the adsorption of salt and alkali by different hydroxides have been investigated

An explanation of these various processes has been advanced from the standpoint of Langmuir's theory of adsorption in which adsorption is assumed to be a sort of loose chemical combination.

Adsorption by barium sulphate.—*By* S. GHOSH.

Freshly precipitated barium sulphate has been found to be a very bad adsorbent for different electrolytes but it markedly adsorbs numerous colloid particles and dyes. The adsorption depends upon the size of the particles that are going to be adsorbed, the greater the size of the particles the greater is its adsorption. It has, however, been observed that barium sulphate adsorbs many ions if an electrolyte is present during the course of its formation, practically in all cases it has been found that the acid portion of the electrolyte is mainly adsorbed leaving the solution distinctly alkaline. It has been clearly observed that barium sulphate acts as an adsorbent and does not form any complex or double salt as has been suggested by a few workers in this line.

The electrode potential of silver in argenticyanide solutions.—*By* B. S. Rao.

With suitable precautions to exclude air, the potential differences between silver and solutions of varying concentrations of pure potassium argenticyanide were determined. An increase in the dilution of the solution makes the electrode more positive to the solution. The effect is too great to be due mainly to the increase in the dissociation of the argenticyanide ion with dilution. Concentrations of silver ion in argenticyanide solutions as calculated from E.M.F. measurements are very small (cf. J.C.S., Aii 607, 1904). The author suggests that adsorption of the argenticyanide ion by the silver electrode is responsible for the low values of the electrode potential.

Adsorption of ions at low ionic concentrations of metal may vitiate solubility measurements as determined by the E.M.F. method. Determination of the solubility of silver cyanide by the E.M.F. method (Morgan, 1895) gives a value only a fifth of that obtained by other methods (Böttger, 1903 and Bödländer, 1904).

To measure the adsorption of argenticyanide by silver, pure silver powder, obtained by the ammonium formate reduction of silver nitrate in dilute alcoholic solution, was shaken with the argenticyanide solution with suitable precautions to exclude oxygen. The method employed for the accurate estimation of silver and cyanide in argenticyanide solutions is described. Experiments indicated the adsorption of both argenticyanide and silver ions by the metal. In O.1N solutions a gram of metal adsorbs about 2 mgms. of the argenticyanide and about 3 mgms. of silver ions.

An adsorption theory of E.M.F. in cells.—*By* B. S. Rao.

The defects of Nernst's solution pressure theory have been frequently pointed out. Experiments carried out by the author indicate that E.M.F. in cells is primarily due to adsorption of ions. Adsorption of ions by an electrode is selective: a metal selectively adsorbs its own ion (e.g. the adsorption of silver ion from argenticyanide solutions poor in the metallic ion, cf. Rudberg and Euler, C.A., p. 1912, 1923). Presumably owing to unsatisfied valency at the electrode surface a metal tends to adsorb an anion—probably hydroxyl ion. The nature and the extent of the electrode potential of a metal is fixed by the relative magnitudes of the two adsorption effects.

Application of the adsorption formula $x \frac{x}{m} = ac^{\frac{1}{n}}$ indicates that the quantity of an ion adsorbed depends mainly on two factors: (1) the ionic concentration, (2) the value of *a*, the adsorption coffiecient. For a metal adsorbing its own ion, *a* is great; but at low ionic concentrations of metal, quantity of the metallic ion adsorbed is small, *c* being minute. Under such conditions, other ions affect the electrode potential, and E.M.F. measurements give no true indication of the ionic concentration of the metal (cf. Dhar, Z. anorg. chem., pp. 57-80, 1921; storgi Nuovo cimento, p. 211, 1921). Some anomalous values of hydrogen ion concentration obtained by the E.M.F. method are probably due to adsorption of ionic complexes.

In a "null solution" the anions and cations an electrode tends to adsorb, balance each other (cf. Billitzer, 1903 and Freundlich, 1909). Null effect in solutions obtained by Palmaer is due to hydroxyl, complex cyanide and sulphide anions that mercury tends to adsorb. Concentration of mercury ion in its null solutions may vary and depends upon the anion causing null effect.

The adsorption theory, unlike the theory of Nernst, is applicable to the potential difference between metal and solutions containing various ions. It takes into account the observed effect of anions on electrode potential. It can also be applied to oxidation and reduction cells.

The electrode potential of mercury in some solutions.—*By* B. S. RAO.

As with silver in argenticyanide solutions, pure mercury was found to become more positive to a solution of potassium mercuric cyanide, with an increase in dilution.

Using a suitable modification of the apparatus used by Billitzer (1903) and Freundlich (1909) the nature of the adsorbed film carried by mercury drops falling through various solutions was indirectly determined. Suitable precautions were taken to exclude oxygen. The mercury used was very pure, being freed from oxide by frequent vacuum distillation. In a solution of potassium mercuric cyanide the adsorbed film is probably of mercuric cyanide.

In a solution of potassium mercuric iodide a red film of adsorbed mercuric iodide is visible. Experiments with phosphate and citrate buffer solutions indicate the adsorption of hydrogen ion by mercury even when pH is nearly 13. A study of concentration cells, built of mercury electrodes and buffer solutions—the phosphate buffer in particular—indicate the possibility of measuring hydrogen ion concentration using a mercury electrode. As the electrode is easily affected by dissolved oxygen such measurements are, however, difficult to make.

Mercury drops falling through caustic soda solution of about 0·15N carry a film of solution richer in alkali while with 0·10N solution the adsorbed film is poorer in alkali. A certain intermediate concentration of alkali must behave as a "null solution" towards the mercury.

The adsorption of ions—hydrogen and hydroxyl in particular—probably complicates our study of electro-capillary phenomena and accounts for certain observed anomalies. The importance of rigorously excluding dissolved oxygen in such experiments is emphasised.

Coagulation of Ferric Hydroxide Hydrosol by Electrolytes.—*By* B. K. VAIDYA *and* A. E. WALDEN.

A ferric hydroxide hydrosol of higher purity than previously obtained has been prepared by a new method of 'hot Dialysis,' described by Neidle Marks.

The precipitating power of several series of electrolytes containing the same anion with this sol was measured, and thus the order of protectiveness of the various cations obtained. The results are in order of the precipitating power of electrolytes.

Chlorides: $Li > Na > K > Mg > Ca > Ba$.

Bromides: $Li > K > Na > Mg > Ca > Sr > Ba$.

Nitrates: $Li > Na > K > Be > Mg = Ca > Sr > Ba$.

The coagulating power of all such electrolytes should be the same (for equivalent concentrations) if the cation had no influence on the coagulation. Hence the cations have different powers of 'protecting' the sol or hindering the coagulation, the order of 'protectiveness' being—

$$Ba^{\circ\circ} > Sr^{\circ\circ} > Ca^{\circ\circ} > Mg^{\circ\circ} > Be^{\circ\circ} > (K^{\circ} > Na^{\circ}) > Li^{\circ},$$

the positions of Na and K being doubtful.

It is suggested that the mobility of the cations may be the chief factor in determining the protectiveness, since the order of mobilities of the cations is—

$$K^{\circ} > Ba^{\circ\circ} > Sr^{\circ\circ} > Ca^{\circ\circ} > Mg^{\circ\circ} > Na^{\circ} > Li^{\circ}.$$

The position of K° is abnormal.

Preliminary Work on Organosols of Ferric Hydroxide.—*By* B. K. VAIDYA.

Organosols of ferric hydroxide in various organic solvents have been prepared by Amberger's method of preparing organosols of noble metals.

Precipitation by electrolytes and cataphoresis experiments have been carried out on an ethyl ether sol. It is found that most of the common organic acids and some inorganic salts which are soluble in ether precipitate the sol. The effect is found not due to any chemical reaction. The sol showed neutral behaviour in electric fields with voltages differing from 110 to 1000.

Further work is under progress.

The electric charge on suspended particles —*By* F. L. USHER.

An attempt has been made to measure the charge on the particles of gamboge in a uniform suspension obtained by centrifuging, by determining the amount of iron taken up by them during their coagulation by a solution of ferric alum. The number of particles in the suspension was determined (*a*) by direct counting and (*b*) by measuring the rate of sedimentation. The result obtained was $e\ 5{\cdot}46 \times 10^{-4}$ electrostatic units. The charge calculated from the mobility of the particles in an electric field by the application of Lamb's formula was $1{\cdot}375 \times 10^{-4}$ e.s. units, and that calculated on the assumption that the particles are isolated charged spheres moving in accordance with Stokes' Law was $5{\cdot}57 \times 10^{-8}$ e.s. units. It is considered that the method employed is defective and must lead to results which are much too high, in consequence of an exchange between the ferric ions and cations already adsorbed by the particles but not contributing to its charge.

The influence of the concentration of the disperse phase on the coagulating value of electrolytes in fine suspensions.—*By* F. L. USHER *and* M. P. VENKATARAMA IYER.

The experiments described by Burton and Bishop (J. Phys. Chem., 1920, *24*, 701) have been repeated and confirmed, and additional experiments have been performed which serve to elucidate the phenomena at least partially. The authors conclude (1) that the quantity of a coagulating ion taken up by a given mass of the disperse phase increases with dilution of the sol, independently of the valency of the ion; (2) that this effect is not due to the operation of a time factor; (3) that it is not due to an increase in the degree of dispersion; and (4) that consequently it must be due to an increase in the effective charge on the particles.

Studies in the mechanism of coagulation by absorption spectra, Part I.—*By* B. LAKSHMAN RAO.

Duclaux has put forward a general theory that coagulation is the result of a chemical action between the precipitating electrolyte and the colloidal solution. The present investigation was undertaken to obtain evidence for or against the above theory by photographing the absorption spectra.

The following four colloidal solutions have been examined :—

Arsenious sulphide hydrosol.
Antimony sulphide hydrosol.
Copper ferro cyanide hydrosol.
Ferric oxide hydrosol.

In the case of the first three negatively charged solutions, the following electrolytes have been tried :—

Sodium chloride, potassium chloride, potassium iodide, barium chloride, cobalt sulphate, chromium nitrate, nickel sulphate, thorium nitrate, aluminium chloride, aluminium sulphate, cerium nitrate and the following for the positively charged oxide hydrosol :—

Sodium chloride, potassium chloride, potassium iodide, potassium bichromate, potassium ferrocyanide, potassium ferricyanide, thorium nitrate, barium chloride, aluminium chloride and aluminium sulphate.

The absorption photographs of the sol electrolyte system when the particles were still in a state of suspension have been taken.

The complete similarity of the absorption spectra of the some colloidal solution when treated with different electrolytes shows that no chemical compounds are formed. That chemical compound formation in a colloidal solution can be detected by this method, has been shown in a previous paper "On the transformation of Realgar into Orpiment and the Analogous behaviour of Arsenious Sulphide Hydrosol." (S.S. Bhatnagar and B. L. Rao, Kolloid. Zeitschrift, Heft 3, Band XXXIII, 1923, p. 159.)

Sonorous properties of gels: Part I, Velocity of sound in rods of silicic acid gels.—*By* M. PRASAD.

Hatschek has classified gels as elastic and non-elastic and has inferred (cf. Introduction to the Physics and Chemistry of Colloids) that silicic acid gels belong to the latter variety. It has been shown by the author that silicic acid gels prepared, by the method of Bhatnagar and Mathur (Koll. Zeit Heft, Bel. p. 368, 1922) are elastic and that the modulus of elasticity increases with the dehydration of the gel. The curves obtained by plotting the deflections of the gel rod against the load applied are very similar to the elastic curves obtained in the case of metals and other elastic substances showing that Hooke's Law is obeyed.

Silicic acid gels have another interesting property of emitting a very peculiar note on striking. It has also been studied by the author and the velocity of propagation of a sound wave in the gel rod has been determined by the formula

$$V = n \, .$$

The velocity of sound in the gel rod was also calculated by Newton's formula

$$V = \sqrt{\frac{E}{D}} \, .$$

and the correspondence of the values of the velocity of sound in gel rods by these two different methods has led the author to conclude that the laws, which hold good in the case of isotropic substances, are applicable to diphasic systems as well.

The mechanism of the protective action of sugars —*By* S. S. BHATNAGAR *and* D. L. SHRIVASTAVA

There are at present three thories regarding the mechanism of protective action of colloids :—

(1) The protective film theory, which postulates the formation of a film round the particles in accordance with the Gibb's Thomson Law.

(2) The electrical charge theory which takes into consideration the increase in the density of the charge on the colloid particles by the addition of a protective colloid.

(3) The chemical theory which postulates some form of chemical union between the protective agent and the colloid particles, as advocated by Langmuir and Zsigmondy.

It is well known that sugars act as protecting agents and they are generally used as peptising agents. Thus it would be interesting to know which of the above theories would explain this action of sugars.

A priori it is clear that the second theory cannot apply in this case as the sugar in aqueous solution does not give charged particles. Thus the choice falls between the first and the third theory. If the first holds good the system simply consists of colloidal particles enveloped in the optically active sugar and thus we will get rotation according to the following calculations:—

Let the original optical rotation of sugar solution be β, and let "a" c.c. of this solution be diluted with an equal volume of colloidal solution.

Now, according to the Beer's Law—

the new rotation $$\theta' = \frac{\beta}{2} - x \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where x is the rotation corresponding to the decrease in the effective length of the tube owing to the presence of colloidal particles.

If on the other hand the adsorption of sugar follows the adsorption theory of Langmuir, the orientation of sugar molecules at the interface between colloid and water would produce anomalous effects.

Careful experiments have been made with the colloidal solutions of arsenic, antimony hydrosulphide sols and copper ferrocyanide sol, and the optically active sugars sucrose, glucose and galactose.

It has been found experimentally that the factor x in equation (1) is negligible and

$$\theta' \text{ is always } < \frac{\beta}{2}.$$

showing thereby that the Beer's Law does not hold and some other factors are interfering.

Thus the possibility of the first theory being right is excluded in the present case and it becomes obvious that the third theory holds in the case of adsorption of sugars, i.e., on adsorption, some chemical action takes place between the sugar molecules and colloidal particles.

Experiments in confirmation of the above conclusions are given, and it is shown that the adsorbed sugar undergoes various physical and chemical changes.

The micro fauna and flora of activated sludge.—*By* GILBERT J. FOWLER *and* N. SWAMINATHAN.

Experiments have been carried out with the activated sludge installation at the Indian Institute of Science to determine among other things the effect of varying air-supply upon the micro-fauna and flora of the sludge. It has been quite clearly shown that excessive development of insect larvae, of various forms of protozoa and of filamentous bacterial forms which are the immediate cause of "bulking" of the sludge are all due to insufficient air-supply. Sludge containing a large proportion of such forms of life is of little use as a fertiliser and it is evident that ample aeration is necessary if the fertiliser side of the question, which is of the greatest importance for India, is to be satisfactorily dealt with.

Enzyme action in the Tamarind.—*By* GILBERT J. FOWLER *and* V. SUBRAHMANYAM, Senr.

In an attempt to follow the changes in the rotatory power of the tartaric acid in tamarind, it was observed that concentrated water extracts of unripe tamarind increased slowly in tartaric acid content on keeping.

Attempts have been made to follow all these changes and correlate them with the changes simultaneously taking place in the concentration of the sugars. The concentrated water extracts were divided into two portions, one kept apart in a sterile flask for bacterial changes while to another enough thymol was added to hinder bacterial action, but not to destroy any enzyme present.

Periodic estimations of sugars and tartaric acid were carried out and the main observation has been that the tartaric acid content increased perceptibly with decrease in content of sugars (reducing and cane-sugar). It was further observed that these changes proceeded in a similar manner for sometime both in presence and absence of thymol. With good growth of yeast like organisms (yet to be investigated thoroughly) there was a very slight decrease in the tartaric acid content with a marked increase in sugar.

It was also noted that the mucilages were broken down at the same time and the solution became perfectly clear with a brown deposit.

The conversion of sugar to tartaric acid seems therefore to be an enzyme change, the mucilages acting as a sugar reserve.

The organism is being studied and the enzyme and bacterial changes followed out with pure sugars.

Studies in the Physiology of the Acetone Bacillus.—*By* GILBERT J. FOWLER *and* V. SUBRAHMANYAN, Junr.

The work on this subject has been directed towards the further elucidation of certain imperfectly understood points in the physiolgical activity of this and allied organisms.

In particular the question of the actual necessity of starch as a food material has been examined and it appears certain that the organism can only really thrive in presence of starch. Starch by-products and sugars generally are only imperfectly made use of. For this reason a mash of mahua flowers is not as good a medium for the acetone bacillus as a mash obtained from jawari or other starch containing cereal.

Further it has been found that the protein requirements of the organism are only properly met by the actual unattacked protein of the grain.

Incidentally the fact has been established that spores of the Weizmann bacillus are capable of remaining alive for at least 7 years in sealed tubes containing maize broth in which they were originally enclosed.

The use of carbonate of soda in the washing of lac.—*By* GILBERT J. FOWLER *and* M. VENUGOPALAN.

In view of the recommendation by various authorities to use carbonate of soda to facilitate the removal of color and other extraneous matters from lac, experiments have been made to determine the critical concentration of alkali which while removing the impurities would reduce the simultaneous loss of resin to a minimum. It has been found that 0·5% concentration of sodium carbonate yields the best results. Comparative trials have been made with borax, soap, etc.

The constituents of raw lac which are removed by washing in this way have also been determined.

Fermentation of Cellulose with Thermophylic Bacteria.—*By* GILBERT J. FOWLER *and* B. N. BANERJI.

Experiments have been carried on to determine how far thermophylic bacteria (operating at 54°C) offer an advantage over the Omelianski organism (operating at 35°C).

To ensure steady and regular fermentation the cellulose must be shredded in such a way that there is no tendency for the pieces to fall together. The sludge used for inoculating must also be in the form of fine mud. Under these conditions the gases formed are able readily to escape.

The reaction of the media should be nearly neutral PH 7·5-6·0. Any increase in acidity has a great retarding influence on the fermentation and ultimately stops it.

The most useful products of fermentation appear to be the combustible gases, methane and hydrogen, the acids and volatile products also formed are present in such high dilution that their economic recovery is impracticable.

If the difficulty of the development of too great acidity can be successfully overcome the process has considerable technical possibilities.

Intensive Nitrification.—*By* GILBERT J. FOWLER, Y. N KOTWAL *and* M. B. ROY.

The conditions have been studied for obtaining high concentrations of nitrate by oxidising solutions of ammonium salts of gradually increasing strength by aerating with a suitably selected activated sludge. Preliminary experiments in large test tubes resulted in the attainment of a concentration of 150 parts per million of nitric nitrogen. In the light of analogous experiments with bacterial filters recently published by Boullanger in the Ann. de l'Institut Pasteur, still better results are being obtained, the maximum concentration so far reached being 2% strength of calcium nitrate.

Mixtures of lac and the resin of *Boswellia Serrata.*—*By* GILBERT J. FOWLER *and* M. RANGASAMI.

Careful comparative determinations have been made of the chief chemical constants of lac resin and of the resin of *Boswellia serrata* when separately dissolved in alcohol and when mixed in varying proportions in alcoholic solution in order to determine if possible whether any chemical combination takes place on mixing. So far there is no evidence of any such combination.

Further experiments are in hand on the effect of fusing together varying proportions of the two resins.

Symbiosis of Seeds and Bacteria, Part II.—*By* GILBERT J. FOWLER *and* MISS R. K. CHRISTIE.

Subsequent to the reading of the first part of this paper at the last Science Congress it has been found that the bacteria associated with the seed are not essential to its germination as good germination has occurred with perfectly sterile seeds but there is evidence that the bacteria are helpful to growth.

Every seed so far examined has a specific extractive of a well-defined basic or glucosidic nature which can be extracted by water or other suitable solvent. These extractives are not always of an antiseptic nature since their action on different types of organisms, e.g. yeast, monilia, B. Coli, Indigo seed bacteria and others, when examined by Delepine's silk thread method, modified to suit the conditions did not show complete destruction of the organisms. It is more likely that they inhibit the immediate activity of the organisms and render them harmless to the seed.

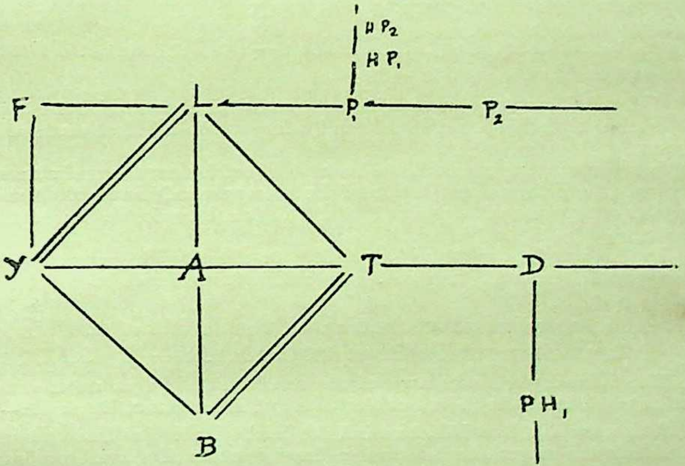
The nutritive value, if any, of the extractives to plants and micro-organisms is at present under investigation. The function of the bacteria seems to vary according to the requirements of different kinds of seeds.

On the constituents of some rare stick lacs.—*By* C. R. SOMAYAJULU *and* M. SRINIVASAYA.

Various specimens of rare stick lacs and seed lacs have been analysed by a new micro method which employs about a hundredth of the quantity commonly required for analysis. An attempt is being made to determine the physiological significance of the constituents having regard to their origin and composition.

Symbiotic constitution of lac association.—*By* S. MAHDIHASSAN.

The author suggests a diagrammatic representation of the various forms of life associated either beneficially or harmfully with the lac-insect and which must be looked upon as constituting one community. In the diagram which is arranged as follows :—



the body of the lac-insect (L) contains yeast like cells, (Y) of a symbiotic fungus. Likewise the tissues, (T) of the plant attacked by the insect contain gum producing bacteria, (B) which there is some evidence to show, act as nitrogen fixers. The close internal relationship in each of the above cases is represented by a double line. The honeydew excreted by the insect appears to owe its origin in part to the symbiotic fungus whose yeast-shaped cells are found in it. Ants (A) by their free movement help in distributing the gum bacteria and the fungus cells, the former help in nitrogen assimilation and the latter promote ammonification of the soil. Ants protect the lac insect and also the tree against the attack of their enemies. This useful relationship of the ant to all four associated forms of life is shown by its central position in the diagram. The flies (F) feed upon the honey dew and in exchange, if any larvae of lac insects attach themselves to the flies, help in their distribution. They also help in the dissemination of the fungus. The lac insects have a number of internal chalcid parasites (P_2) and external predacious caterpillars of moths (P_1). Their parasitic relationship is clearly shown on the diagram. These caterpillars are liable to the attack of several hyperparasites (HP_1, HP_2). The tree also has its defoliators (D) and other injurious insects, some of which in their turn fall a prey to parasitic hymenoptera (PH_1). Those insects which are indirectly beneficial to lac are represented on lines at right angles to the lines connecting respectively the lac parasites or the tree defoliators with the lac insect or the tree tissue.

Acacia Farnesiana as an experimental and commercial host plant of lac.—*By* M. SRINIVASAYA.

It has been found that *Acacia Farnesiana* has continued a brood of lac to its seventh generation whilst maintaining its vitality at a remarkably steady number. As this plant can be rapidly and easily grown it would appear to be an excellent host plant for lac, at any rate for the maintenance of satisfactory strains of brood lac and for experimental work.

Latterly it has been found that lac can be readily grown on *Acacia Farnesiana* plants maintained in water culture. In this way interesting comparative experiments in nutrition can readily be carried out and a possibility, foreshadowed some ten years ago, of growing lac experimentally in the laboratory is an accomplished fact.

Bio-chemistry of Fallen Leaves.—*By* GILBERT J. FOWLER *and* R. D. REGE.

A detailed investigation of this subject is being made with the object of the more scientific use of leaves and other waste cellulose material as manure.

Very interesting results have been obtained by aerating mixtures of finely powdered leaves and activated sludge suspended in water. A rapid reaction takes place with production of a dark coloured solution containing large quantities of 'humin'

In this way it would appear possible to effect, with great rapidity, changes which normally require long periods of time for their completion.

A bio-chemical investigation of the action of certain low forms of vegetable life on textile fabrics.—*By* D. L. SEN.

The following is a summary of the results obtained in an investigation carried out at the School of Technology, Manchester, England :—

It is shown in Part I that an infinitesimal quantity of food material, suitable to the requirements of micro fungi is naturally present to some extent in all raw cottons and if these are exposed to a moist, warm condition for a prolonged period of time micro-fungi make their appearance.

It has been observed that the micro-fungi first appear on the surface of individual fibres and send their mycelium right through the canal of the cotton hair.

In Part II experiments were first carried out with five different samples of fabric, two of which were uniform in structure, the remaining three being average specimens for tropical markets, representing three grades of sizing—light, medium and heavy. Mildew appeared in all the fabrics, with the exception of one uniformly scoured sample, after exposure to a moist warm condition for over 30 days at 22·2°C. It was found also that the growth of mildew is approximately proportional to the quantity of foodstuffs present in the fabrics in the form of size materials.

Further experiments showed that scouring seems to remove all direct food materials from the fabrics.

In Part III experiments were made to investigate the effect of sizing the yarns with different kinds of starches. It was observed that "Tuber starches" were more susceptible to the action of micro organism than "Cereal starches"—a fact of considerable practical importance.

Finally preliminary experiments were made as to the possibility of using gaseous antiseptics in warehouses, without actually using any antiseptic in the size. The use of formaldehyde seemed promising.

The Biogenesis of Mahua Oil.—*By* GILBERT J FOWLER *and* T. DINANATH.

A systematic investigation has been made of the changes taking place in the fruit and seeds of *Bassia Longifolia* from their first appearance, up to the stage of complete ripeness.

Periodic chemical analyses by ordinary methods have been correlated with the micro-chemical examination of carefully prepared sections.

The results generally are in accordance with those of previous workers on allied problems.

In particular it has been found that at a certain stage of development the changes in the seed occur independently of those in the husk or pulp, whereas before that there exists an intimate connection between the two.

There is evidence that the oil is formed in the seeds at the expense of carbohydrates and possibly of tannins.

At the outset free fatty acids are formed which are later converted into glycerides.

In the husk the results point to an initial formation or sugar with subsequent increase in starch.

The proportion of proteids in the seeds shows little variation, while in the husk the nitrogen percentage is found to rise to a maximum and then decrease.

The relation between surface tension and vapour pressure of liquid organic mixtures, Part II.—*By* N. A. YAJNIK *and* M. C. BHARDWAJ.

The work has been continued further and the following new mixtures have been studied:—

(*a*) Type I. Mixtures, the vapour pressure curves of which correspond with the theoretical straight line (i) bromobenzene and toluene, (ii) chloro-benzene and toluene.

(*b*) Type II. Mixtures, the vapour pressure curves of which lie below the theoretical straight line (i) pyridine and propionic acid, (ii) ethyl iodide and methyl alcohol.

(*c*) Type III. Mixtures, the vapour pressure curves of which lie above the straight line (i) ethyl iodide and carbon tetrachloride, (ii) acetone and carbon disulphide.

The surface tension curves obtained are similar but of the reverse type to vapour pressure curves.

The validity of Whatmough's and Volkmann's admixture formulæ has been studied. It is found that their application is not universal as no account is taken of association and dissociation in these formulæ.

The relation between viscosity and vapour pressure of liquid organic mixtures, Part II.—*By* N. A. YAJNIK *and* M. DATT.

The work has been continued further and the following new mixtures have been studied:—

(*a*) Type I. Mixtures, the vapour pressure curves of which correspond with the theoretical straight line (i) bromobenzene and toluene, (ii) chlorobenzene and toluene.

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The viscosity curves obtained are similar but of the reverse type to the vapour pressure curves.

The validity of (*a*) Bingham's fluidity formula, (*b*) the linear formula, (*c*) Kendall's logarithmic formula and (*d*) Kendall and Monro's formula has been tested. They are found to be of limited application, as they do not take into account association and dissociation.

The relation between viscosity and surface tension of liquids, Part I.—*By* R. K. Sharma.

The present work was undertaken with a view to determine some relation between viscosity and surface tension of liquids. Water, methyl and ethyl alcohols, benzene and acetic acid were examined. As a result of the investigation the following results have been arrived at :—

(1) When the surface tension of a liquid increases viscosity also increases, and when it decreases it also decreases.

(2) When the log of viscosity is plotted against the log of surface tension we get a straight line and the following general equation can be used to express the relationship—

$$\text{Log } y = M \log X + c \text{ ;}$$

y represents the surface tension of the liquid,

X represents the viscosity of the liquid,

M represents the slope which the straight line makes with the positive direction of the X-axis,

c represents the intercept of the straight line on the Y-axis,

$$\frac{y^3}{T^{13}}.$$

(3) Y represents the viscosity of the liquid.

T represents the surface tension of the liquid.

(4) The "heat of surface tension" is $\frac{1}{6}$ the "heat of viscosity."

The Relation between Surface Tension and the Vapour Pressure of Liquids, Part I.—*By* R. K. Sharma.

The present work was undertaken with a view to determine some relation between vapour pressure and surface tension of liquids. The following conclusions have been arrived at :—

(1) If we take two liquids and determine their surface tension over a very large range of temperature we can find certain temperatures at which their surface tensions are the same. If we plot the curve taking T and T/T_0 as the axis a straight line is obtained. T_0 is the absolute temperature of the standard liquid and T of the other liquid. The formula $F(s) = A + B/T$ can be used to express the relation.

(2) The log of vapour pressure is a linear function of the reciprocal of its temperature and the slope of the line is a measure of the "heat of evaporation."

(3) The hyperbolic nature of the curve obtained on plotting the surface tension and vapour pressure shows that surface tension is a linear function of its temperature.

(4) The log of surface tension when plotted against the log of vapour pressure is a straight line.

(5) It has been possible to arrive at an equation $XT^{18}=K$.
 X represents vapour pressure, and
 T represents surface tension.
 K is independent of temperature for any particular liquid but is different for different liquids.

(6) The significance of the exponent 18 is that the slope of the surface tension straight line is $\frac{1}{18}$ the slope of the corresponding vapour pressure line.

(7) When surface tension reaches infinity vapour pressure is zero and vice versa.

The Relation between viscosity and vapour pressure of liquids, Part I.—R. K. SHARMA.

Porter (Phil. Mag., vol. 23, p. 458) finds out that if the log of viscosity be plotted against the log of vapour pressure a straight line is obtained. His equation is not general and involves the determination of two constants. An attempt has been made to arrive at an equation of a more general nature and one which involves only one constant. Water, ethyl and methyl alcohols, benzene and acetic acid have been studied. As a result of the present investigation the following results have been arrived at:—

(1) The log of the vapour pressure of any liquid is a linear function of the reciprocal of its absolute temperature and the slope of the line is a measure of the 'Heat of Evaporation.'

(2) The log of viscosity is a linear function of the reciprocal of its temperature.

(3) $XY^3=K$.
 X represents vapour pressure,
 Y represents viscosity,
 K equals a constant.
 K is a constant which is independent of temperature for any particular liquid but is different for different liquids.

(4) The significance of this exponent 3 arrived at in the above equation is that the slope of the viscosity straight line is $\frac{1}{3}$ the slope of the corresponding vapour pressure line, or in other words, the "heat of viscosity" is $\frac{1}{3}$ the "heat of evaporation."

(5) When vapour pressure is zero viscosity is infinity and vice versa.

Temperature co-efficients of photo-chemical reactions.—*By* N. R. DHAR.

The temperature co-efficient of thermionic emission is very large, whilst that of photo-electric emission is practically unity. Ordinary chemical reactions carried on in the dark are expected to obey the same laws as govern the emission of ions from heated elements, whilst ideal photo-chemical changes should follow the same laws as are found in photo-electric emission.

In reality, ideal photo-chemical reactions are very rare and that is why the temperature co-efficients of many supposed photo-chemical reactions are usually greater than unity.

The Boiling Points of Solutions in Methyl Alcohol under Reduced Pressure.—*By* A. R. NORMAND *and* R. K. ASUNDI.

1. By means of an apparatus which depends on the dynamical method of effecting a constant leak from atmospheric pressure, the mole-

cular elevations of solutions of a number of electrolytes and organic substances in methyl alcohol were determined at 30°C.

2. It was found that—

(*a*) acetanilide and diphenylamine behave as normal substances:

(*b*) the molecular elevation increases as we increase the dilution in the case of KI, NH_4Br, NEt_4I, and NPr_4I;

(*c*) it decreases as we increase the dilution in the case of NaI; and

(*d*) it has the same value at all dilutions investigated in the case of $CoCl_2$, NH_4I, NH_4Cl, and NaBr.

3. The results for substances in 2 (*b*), when viewed from the standpoint of Ghosh's theory, generally agree with it but the theory needs modification.

4. Ostwald's dilution law is obeyed by NEt_4I and NPr_4I when the degree of dissociation is calculated by the Arrhenius equation. KI and NH_4Br do not follow it. They obey, however, P. Walden's dilution equation.

5. It was found that the ratio of the molecular elevations for NEt_4I and NPr_4I is a constant independent of dilution, thus indicating a quantitative relationship in the boiling point elevations of solutions of homologous compounds.

Viscosity of emulsions.—*By* S. S. Joshi.

The emulsions were prepared from castor, olive and paraffin oils, mixed with differently concentrated solutions of potassium oleate, palmitate, stearate and sodium oleate. The volume-ratio of the aqueous and the oil phase was varied so as to get both the types and viscosity of the emulsions was determined at each phase-ratio. Increased proportion of the dispersed phase showed an increase in the viscosity of the emulsion, being maximum at the reversal point and decreasing rapidly at the subsequent phase-ratios. With markedly viscous oils reversal did not occur at a single phase-ratio, the viscosity of the system gradually and rapidly decreased within about three phase-ratios, the emulsion exhibiting a partial reversal, and then showed the small value found to be the characteristic of oil-in-water emulsions. Further work showed that this region of mixed type is a general phenomenon; it is wide in the case of very viscous emulsions and is narrowed to one or two phase-ratios with more fluid emulsions.

Possibly, the continuous increase of the viscosity of the system, as the inversion point is approached, is due to a corresponding increase in the size of the grains. The reversal point is where the grains assume their optimum size and the system shows maximum viscosity. This is exactly what is observed with other colloid solutions, approaching the coagulation point; and the viscosity data in the present paper give an independent and a fresh support to the analogy between the coagulation of suspensions and the reversal of the type of emulsions put forward by Dr. Bhatnagar (Symp. on Colloids, Farad. Soc., 1919) and also by C. H. Clowes.

Further it was found that the viscosities of the above emulsions, especially at low proportions of the aqueous phase, were in approximate agreement with those calculated from the equation given by Einstein (Ann. Phys., 289, 1906; 891, 1911). At subsequent phase-ratios viscosities found were greater than those expected from the above equation. On determining the specific gravities of these emulsions it was found that the mixture-law was approximately valid; no larger volume-changes were, therefore, involved on emulsification. At greater proportions of the aqueous phase specific gravities found were slightly greater than those given by the mixture-law: at low proportions of the dispersed phase, the agreement was found to be better, and it was just in these cases that Einstein's viscosity equation was found to be approximately applicable.

The electrical conductivities of some monovalent salts of higher fatty acids in non-aqueous solvents and in the fused state.—*By* S. S. Bhatnagar *and* M. Prasad.

McBain and his co-workers (J. Chem. Soc., T. 957, 1914) have shown that the solutions of alkali salts of higher fatty acids in water show a very high electrical conductivity. As a result of E.M.F. determinations it has been concluded that in the above cases the current is not carried by simple sodium and acid radical ions. They have attributed the cause of high conduction to highly-charged aggregates or micelles. Authors have studied the electrical conductivities of the solutions of alkali salts of oleic, palmitic and stearic acids in ethyl, propyl, butyl, amyl alcohols and pyridine and also in the fused state. It has been shown that their equivalent conductivity increases with dilution (Kohlrausch) but the curves obtained by plotting equivalent conductivities against dilution are straight lines and not parabolas as required by Ostwald's dilution law. This anomaly is probably due to the need of viscosity correction. Since no data on the viscosity of the above salts in organic solvents are available, work on the viscosities of these solutions is in progress and will be shortly communicated.

The conductivity of soaps in the fused state has been determined by the direct as well as by the alternating current, and it has been observed that in all cases the conductivity determined by alternating current is greater than that determined by direct current. This difference has been accounted for by regarding the conduction in soaps in the fused state as electrolytic and not metallic and is due to polarising effects which are observed in electrolytic conduction by direct current. Also the increase in conductivity with the rise of temperature points to the same effect; for the relation of temperature with metallic conduction is

$$R_t = R_0 (1 + at),$$

which would indicate that the conductivity would decrease with the rise in temperature.

Contraction on solution.—*By* J. N. Rakshit.

Contraction on solution of 100 gms. of substances in water, aqueous alcohol and alcohol have been studied by the determination of sp. gr. of their solutions. In some cases, the contraction increases or decreases with increasing dilution, whilst in others the contraction increases, passes through a maximum, and then decreases with decreasing dilution.

Oxidation of *p*-Cymene into Thymol.—*By* D. N. Das Gupta.

Attempts have been made to oxidise *p*-cymene into thymol by the following methods of oxidation :—

(*a*) By ozone in the presence of metallic and "metallic oxide" catalysts.
(*b*) By hydrogen peroxide in the presence of colloidal metals.
(*c*) By anodic oxygen.

It has been found that in some cases *p*-cymene is oxidised directly into thymol. Further work on this subject is in progress.

On the influence of ultra-violet light on the systems KI, KNO_3 and KI, $KClO_3$ in neutral solutions.—*By* K. Suryanarayana.

A perfectly neutral solution of KNO_3 is found to be decomposed by ultra violet light with the formation of KNO_2 and the liberation of oxygen. In neutral solutions KNO_3 acts on KI under the influence of ultra violet light with the liberation of iodine. Similar is the case with $KClO_3$. The mechanism of the changes and their kinetics have been worked out. Incidently the photo-chemical decomposition of KI solution has also been studied.

Reduction of Perchlorates in the wet way.—*By* M. V. NARASIMHASWAMY.

Excepting the single observation of Sjollema (Zeit. anorg. Chem., 1904, 42, 122–128) on the reducing action of ferrous hydroxide on pot. perchlorate and the practice of Knecht and Hibbert (See New Reduction Methods in Volumetric Analysis) of using Titanium Chloride as the reducing agent, other more efficient reducing agents were not tried with regard to the reduction of perchlorates. The method of Knecht cannot gain extensive practice on account of its costliness and Sjollema's observation is only a qualitative one. The object of the present investigation is to try the action of active hydrogen, in all the circumstances in which it is originated with a view to the quantitative reduction of perchlorates. A systematic investigation of the reducing power of the ower states of oxidation of metals of polyvalent habit is also undertaken.

The details of the experiments and the results obtained are given in the original paper.

The preparation of *Ash* of food-grains for analysis.—*By* S. KASINATHA AYYAR.

Much difficulty was experienced in obtaining carbon-free ashes in the case of food-grains.

Addition of silica before ignition gave a good ash and was finished much more quickly than the official method.

Concordant values for ash were obtained.

No loss of phosphoric acid was observed as was reported.

Cholam (Andropogan Sorghum) as a substitute for Barley in Malting operations: The Hydrolysis of starch by Cholam Malt Extract.—*By* B. VISWANATH *and* M. SURYANARAYANA.

From an investigation into the hydrolysis of starch by cholam Malt extract it appears that two enzymes are responsible for the degradation of starch into maltose, (1) an *amylase* converting starch into dextrine, and (2) a *dextrinase* further hydrolysing the dextrine into maltose. Unlike Barley, comparatively larger quantities of dextrines are produced, but with lower specific rotation and higher cupric reduction, and the production of maltose is suppressed by rise of temperature until at last with Malt extract heated to 85 degrees for half an hour no maltose is formed. The fact that no maltose could be detected up to one hour's progress of the reaction shows that the dextrinase of cholam Malt does not assert itself, until the degradation is sufficiently advanced.

Section of Zoology.

President :—PROF. K. N. BAHL, D.SC., D. PHIL.

Presidential Address.

THE ORGANISATION OF ZOOLOGICAL TEACHING AND RESEARCH IN INDIA.

We are met this year for the second time in a city made known to the scientific world by the foundation of the Indian Institute of Science in which this Congress met when it visited Bangalore last time. Outside Bangalore, we associate with this town not only the memory of the benefactor of the Tata Institute, Jamshed Tata, whose princely gift represents perhaps the first and foremost endowment by an Indian millionaire for the training of his countrymen in research, but we also associate with this town a general scientific atmosphere, an atmosphere of research to which doubtless both the Central College and the Tata Institute contribute together. In an atmosphere like this, it is fitting for us Zoologists in India to inquire if all is well with our branch of Science, to take stock of our present position and find out what we have neglected and what are the lines of work that are most urgent and likely to yield results. I value highly the honour of addressing you as President of the section and crave your indulgence as I make a few observations on the organisation of zoological teaching and research in this country.

This Congress does not concern itself with problems of teaching but I have ventured to keep teaching and research together as I advocate most strongly the combination of teaching and research. Unfortunately in India there has been a marked tendency towards a divorce between research and teaching and I consider that such a divorce is very much to be deprecated. It has had a bad effect on the universities and an equally bad effect on our Research Institutes. Zoological research in India is carried on either at the Universities or at the Zoological Survey of India, besides Entomological work at Pusa and Dehra Dun. Some entomological work is also being done at various provincial agricultural colleges while isolated private workers publish papers on Natural History subjects. The Zoological Survey and the Imperial Research Institutes are more or less isolated from the universities.

Indian Universities have not been able to make adequate contributions to the advancement of knowledge because the time and energies of the staff are taken up in a ceaseless round of teaching. In the Research Institutes, on the other hand, individual workers have conducted research on their own lines, often with admirable results, but there has been very little organised training of students in research with the result that gifted workers in these institutes who have done magnificent work themselves have not had the men whom they could inspire and thus found a school of continuous research. Systematic post-graduate work could be done nowhere better than at these Imperial Institutes, but unfortunately we have neglected to make use of these opportunities.

The universities have to share the blame to a considerable extent. The result of want of a liaison between teaching and research is nowhere so apparent as at Calcutta. The Calcutta centre of zoological research occupies the premier place in India and has an unbroken record of zoological work going back nearly for a century. To Dr. Annandale, the Director of this centre of research and our President this year, is due the credit of inaugurating a scheme under which promising Indian students are trained in methods of research. The scheme has been successful in that all the research assistants appointed have turned out good work but the Director in his recently issued report complains of the difficulty experienced in filling up assistantships as they fall vacant. The reason is obvious. The Calcutta University, so active and go-ahead in other directions, has failed to make use of the splendid galleries and the well-stocked libraries of the Indian Museum. In fact, the Calcutta University could have a school of zoology without paying for it. The Museum and the Library which are the only things that really cost money are already there, but somehow the University has never taken up Zoology seriously. I am sure the Research Assistants scheme would never have suffered if the Calcutta University had made use of its opportunities in Zoology. Almost all the research assistants had to be brought over to Calcutta from the Punjab since there were no men available at Calcutta.

The Dehra Dun and Pusa Institutes have explicitly or implicitly maintained in the past that they are research institutes only and can undertake no teaching. The initial mistake made in their case, of course, was that they were not attached to any university, but having been established at isolated centres, the next best thing would have been to make them centres of post-graduate training in research. The Pusa Institute has just made a move in the right direction and adopted a scheme for training graduates in research in all the departments of the institute. The experiment will be watched with great interest and I have no doubt that with proper care it will succeed.

The Dehra Dun Institute still lags behind and makes no provision for training men in research. It would even seem to neglect the very purpose for which it exists. Mr. Perée, the

Director of the Institute, writes: "There is no organised training of the new recruits on their arrival in India, and the existing practice is to leave this to the provinces and practically nothing is done to train the newly arrived officer or help him in the study of Indian conditions and problems." No wonder that the ordinary forest officer is a mere administrator and not a specialist engaged in finding out the best means of utilising our forest resources.

The fact is that systematic post-graduate work has played a very small part in the life of universities and has not been encouraged even in our Imperial Research Institutes. It is a hopeful sign that universities in India are now making increased provision for research and are realising that just as it is their function to turn out good citizens, so also it is their function to turn out good researchers, and thus to advance knowledge. When sound zoological training is available in India, it should be unnecessary for a large number of students to go abroad for such a training. I agree with Dr. Annandale when he says that "European experience is important in the later period of a zoological career and is unnecessary until the student has absorbed the spirit of research." How best to infuse this spirit of research amongst our students? The example of the teacher engaged in research certainly goes a long way but beyond that what is needed is to require from every student of science a certain modicum of research as one of the qualifications for his final degree. Every science student should have an excursus in research since the prosecution of research is the only means of instructing in research. We at Lucknow have instituted the M.Sc. degree which would be taken by a year's research after the B.Sc. Honours stage, and I understand that they have done the same at Lahore. Some people are very doubtful if this final year at the university spent in the solution of an actual problem would result in very much and they have condemned the scheme, so to speak, in advance. To my mind it matters less what the student's measure of successful result is than that he should embark on the voyage on his own towards some horizon of his subject. The outlook of a student who has carried out one single research of an elementary kind is bound to be different from that of one whose look out is derived solely from the text-book and the examination. The former would get ideas of scientific truth and of the scores of errors which lie in wait around it, as may be acquired in no other way. All of us learn by making mistakes and it is certainly a step forward to give our students an opportunity to learn when mistakes can be easily found and checked. With this excursus in research, our students will go out well-equipped for facing and attacking new problems.

I have no fad for pure science as against applied science. The application of scientific knowledge for the good of mankind is as old as that knowledge itself and the majority of those who have attempted this application have not been swayed by any pecuniary motive. In India, Agriculture is our main industry and the urgent problem of the economic betterment of the bulk of the population depends upon agricultural improvements. If researchers in zoology at the universities were in close touch with agricultural research, they could benefit not only agriculture but could also extend the influence of the universities over the State by valuable assistance given to the agriculturist. There is no class of the community in our country more in need of assistance than the agricultural and it is up to us, if we can, to help to solve the problems of this community. While I am at the question of agricultural research, it is worth noting that no university in India provides a full course in entomology. It would seem that such a course is very necessary in a country which requires the services of a large number of well-trained entomologists to conserve and utilise its wealth in forests and cultivated land. It is certain that the demand for trained entomologists is bound to grow in this country with the increasing development of our agricultural and forest resources.

One of the serious difficulties in the way of any investigator is his isolation from libraries. Our library resources in India are admittedly poor and good zoological libraries are very few. The library is the heart of all research work; but we in India have thought more of laboratories than of libraries. There are many finely fitted and well equipped zoological laboratories in India but I should like to see equally well-stocked libraries at several places. Three years ago, a professor in England asked me what exactly it was that was wanting in the way of facilities for research in India. I told him we lacked two things only—men and libraries. The vital necessity for a well-equipped library is not so well realised yet in our country as that of a well-equipped laboratory. Our attention was drawn pointedly to this weakness in our system four or five years ago and a librarians' conference was held at Lahore. What came out of it, I do not know. We in U.P. have four universities, three teaching Zoology up to the M.Sc. standard, and we have come to an understanding amongst ourselves not to have duplicates of the same journal at all the places—at least the sets of back numbers. Each of us has a list of sets available at the other universities, so that we may have as many sets of different journals as possible between us. We freely exchange amongst ourselves our journals, and we hope that in course of a few years, we shall have most of what we want by way of literature in Zoology amongst us. This plan minimises our expenditure a good deal as it is impossible for a single university in these days to subscribe to all journals issued in the world; at the same time we get the use of so many journals by this co-operation.

Another of our needs keenly felt in the laboratories is a series of detailed descriptions of the structure of common types of animals. We still use British text-books which take the British fauna as their basis; but we have to give our students Indian types for examination and dissection in the laboratory. Very little has been done towards providing our students with adequate descriptions of common Indian types. I propose that we should issue a series of memoirs like the excellent series issued by the Liverpool Marine Biology Committee under the editorship of Prof. Herdman, commonly known as the L.M.B.C. memoirs. I am sure such a series is urgently needed and will be greatly appreciated by students and teachers alike. Here is an opportunity for work by several researchers and I think we shall have accomplished a very great deal indeed, if at this annual gathering of zoologists, we can agree upon a scheme of such memoirs and are also able to assign the types to various workers. We can make a good beginning with the following types:—

1. A Polychaete.
2. The Earthworm Pheretima.
3. Leech (Limnatis).
4. Starfish from Ennur.
5. Prawn.
6. Scolopendra.
7. Scorpion.
8. Ampullaria.
9. Dogfish (Carcharias).
10. Lizard (Uromastix or Varanus).

In selecting these types, care has to be taken that these should be as far as possible all-India types which should be made use of in all parts of the country. I have myself nearly completed a description of the Earthworm Pheretima and shall soon be taking up the Dogfish (Carcharias). These two genera of animals are studied as types not only in India proper but throughout Greater India, if I may use that term to include Burma and Ceylon. The other eight types could be taken up at once by other workers and I have no doubt that in course of time we could have a series of monographs on the various Indian types which we may justly feel proud of. I would request members of the section to express their views on this subject so that we may be able to decide on our course of action without delay.

Closely connected with the question of these memoirs is the question of a Marine Biological Station. A good bit of Zoology is Marine Zoology. Up till recently we obtained all our marine specimens from Plymouth and Naples, but now-

Ennur supplies a good deal of our wants in that direction and the supplies, as far as they go, have been perfectly satisfactory. We need a further development of this source of our marine supplies and also want that there should be attached to it a laboratory where our students could go and work for a few weeks and thus make a first-hand acquaintance with the marine fauna. The need is felt very keenly by us in inland towns where a large number of students have never had an opportunity even to visit the sea. A visit to such a marine station would be of immense benefit to our senior students. Lots of work on the Indian marine types could be carried out at such a station. How much the scope of biological research will be enlarged can be realised from the fact that most of the recent experimental work in fertilization and parthenogenesis has been carried out at marine stations. I have not seen the Ennur station myself and am not acquainted with its situation and equipment but it is certainly necessary that we should set ourselves to think about it and I have no doubt that if a well-considered scheme were put forward, the universities in India would help such a scheme and we can have a Marine Station going at no distant date. Our country is a country of long distances and I am not sure whether it would not be advisable to have two or three stations—in the north and in the south. Karachi would be quite a good place and I understand some preliminary faunistic work has been done by the Lahore people there. Other places would probably suggest themselves to other members and we could exchange our views on the subject here. Officers of the Zoological Survey have a scheme of having a biological station at Port Blair in the Andamans. It would probably be an excellent place in other ways but I am very doubtful whether it would be so easily accessible at all times to students from all parts of India, as a place on the mainland would be. In any case, the question is worthy of serious consideration and it is up to us here to formulate a scheme and do our best to carry it through by each of us influencing his own university.

The question of a Journal of Zoology may now be considered. Sir M. Vishvesharaya in his Presidential Address at the Lucknow Congress last year urged the desirability of all research work carried out in India being published in this country. It is an admirable idea and I am sure most of us will agree with it I must plead guilty myself of having published abroad the results of some of my work done in India. The 'Records of the Indian Museum' is now a well-established journal of recognised standing and has been in existence for a number of years. I still fondly remember that I made use of the hospitality of its pages for publishing my first paper. The journal publishes primarily the results of faunistic and taxonomic work, but if one were to scan its pages one would find that papers of other descriptions have also appeared from time to time. If we were to classify Zoology, broadly speaking, into three categories, namely—(i) Descriptive and Systematic Zoology, (ii) Experimental Zoology and (iii) Philosophical Zoology, I consider that the Records should publish mainly papers falling under the first category (Descriptive and Systematic) and may include papers of the third group also. The first category will include Morphology comprising Anatomy, Histology and Cytology; Embryology, Palæontology, Systematic Zoology; Anthropology and Zoo-Geography. As most of the zoological work done in India can be grouped under these headings, the Records will record almost all Indian zoological work. Experimental Zoology is a comparatively new development and although it has a large number of workers devoted to it elsewhere, in India it has not yet claimed many devotees, but in course of time we may be able to publish work of this kind also. Co-operation of the universities will hasten the attainment of the object I have in view. It should be possible, for instance, to associate the teachers in various universities in the editorship of the "Records." Given good-will on all sides, we could make the Records a truly representative Indian zoological journal.

Gentlemen, I have done. It remains for me now to express my deep sense of disappointment at being unable to be present at the Congress myself. Nothing would have given me greater pleasure than to have listened to the criticism of the observations I have made but forced as I have been by circumstances beyond control, I have to deny myself that pleasure and opportunity.

The Presidential Address was followed by an interesting discussion as an outcome of which the following conclusions were arrived at:—

1. It is not desirable, even if it were practicable, to add to the already cumbrous number of zoological journals. The publications of the Zoological Survey of India and of the Asiatic Society of Bengal afford a suitable medium for the publication of zoological work carried out in Indian universities. The former are, for financial reasons, at present practically restricted to the publication of the results of the work of the Zoological Survey; but the latter could and should be much more fully utilized by research workers, especially now that the papers in the 'Journal' are grouped according to their subject in separate numbers.

2. Dr. Annandale agreed to bring this matter to the notice of the editors of the Asiatic Society publications, and to ask them to publish special memoirs on Indian types, on similar lines to the L.M.B.C. memoirs in England, issuing a number of reprints for separate sale. He promised one such

memoir on *Pachylabra* (Ampullaria) by Dr. Baini Prashad, and one on the Earthworm *Pheretima* is promised by Prof. Bahl, who intends to follow it by one on Dogfish (Carcharias).

3. The scheme of the Zoological Survey for a Marine Biological Station in the Andamans was felt to be most desirable, and it is hoped that every effort will be made to press on with it in view of the exceptionally favourable conditions found there for work in many fields of Zoology. It is primarly intended, however, to meet the needs of advanced research workers; in view of its comparative inaccessibility it is unlikely that it can be made to meet more general needs. It was therefore felt to be imperative that at least two stations should be established on the Indian coast, one for the northern, the other for the southern universities of the country; it was pointed out how far we are behind Japan where every university has such a station in connection with it. Karachi and Krusadai Island were mentioned as possible sites in the north and south respectively. Prof. Bahl, Dr. Annandale, Prof. Bhatia and Mr. Awati were asked to consider the northern scheme, and Dr. Sundra Raj, Prof. Narayan Rao, Mr. R. Gopalan and Dr. Gravely the southern, and report to the Friday morning's session of the section. These committees found that the botanical section was as keenly interested in the matter as the zoological section. Their resolutions were therefore discussed by both sections, where they were slightly modified and passed unanimously in the following form :—

(1) The Zoological and Botanical Sections of the Indian Science Congress have had brought before them the urgent need in India for Marine Biological Stations where students and approved workers can obtain a practical knowledge of marine organisms and do research work, as they do in the stations attached to every university in Japan, as well as in England and elsewhere. We heartily endorse this plea for immediate action.

(2) We believe Krusadai Island to be the most suitable and convenient place for the establishment of such a station to meet the needs of the Universities of Madras, Mysore, Travancore, Bengal and probably Benares and some other universities in Northern India. We therefore hope that the Madras Government will postpone the proposed sale of this island for three months, to permit of definite proposals being framed and means found for carrying them out.

(3) We are further of opinion that a second Biological Station should be established at Karachi, primarily for the use of the universities of Western and North-Western India.

(4) We request the Hon. Secretaries of the Congress to communicate the above resolutions to all the Indian universities and the Local Govts. or Durbars under which they work (except that the third resolution which does not concern

them, should not be communicated there). Replies concerning the Krusadai station may be forwarded to the Southern Committee through Dr. Gravely and those concerning the Karachi station to the Northern Committee through Prof. Matthai.

Divergent Evolution.—*By* N. ANNANDALE.

Considerable attention has been paid to the phenomenon of Parallel Evolution or Convergence since the days of Wallace and Darwin, but the opposite phenomenon, that of Divergent Evolution, has been little noticed. Divergent Evolution occurs when allied organisms exhibit widely different modifications in correlation with the same or a similar type of environment. This phenomenon seems to be commoner among the lower groups, and especially among the sponges, than among the higher groups. It is far from uncommon in the circulatory system of sponges. Instances are given from this group, from the Echiuroids, the molluscs, the beetles, the termites and the batrachian larvae, and the phenomenon is discussed in reference to the transmission of acquired characters and the survival of the fittest.

The Molluscan Hosts of the Human Blood Fluke.—*By* N. ANNANDALE.

Three species of human blood fluke are known, namely *Schistosoma haematobium*, *S. mansoni* and *S. japonicum*. The last is widely distributed in China and occurs also commonly in certain districts of Japan, in Formosa and in French Indo-China; *S. haematobium* and *S. mansoni* occur in most parts of Africa, while the former has also been found in Portugal, Mesopotamia and Asia Minor, and the latter in South America, into which it has probably been introduced accidentally. The hosts of the first two species probably belong as a rule to the family Planorbidae and to the genera *Bullinus* (=*Isidora*), *Physopsis* and *Planorbis* (*s.l.*). Possibly, however, the parasites may occur occasionally in *Limnaea*. The hosts of the far-eastern species belong to a different family and order. They may all be placed in the genus *Oncomelania* Gredler, of which *Katayama* Robson is a synonym or at most a division. *Blanfordia* Adams, which is not really implicated, is quite distinct.

Some Observations on the Fauna of the Punjab Salt-Range.—*By* S. L. HORA.

The Punjab Salt-Range is an isolated hill-tract in which desert or semi-desert climatic conditions prevail for a considerable part of the year. Moreover, the soil is impregnated with mineral salts, which greatly influence both aquatic and terrestrial animals. The fauna of the range, affected as it is by adverse conditions, is poor but interesting. It contains an element of the Afghan fauna and a considerable proportion of endemic forms. Two palaearctic species have also invaded this region; of these one (*Bithynia tentaculata*) has not hitherto been known south of Kashmir.

The Siji Cave and Observations on its Fauna.—*By* B. CHOPRA.

The existence of a large cave in the Garo Hills, Assam, has been known for many years. The paper is a summary of the results of an investigation undertaken by Dr. S. W. Kemp and myself with a view to work out the fauna of this cave. With the help of a plan the topography of the cave is briefly described. After mentioning the topographical features that have a bearing on the fauna a table of animals found in the cave is given. The conditions affecting the land and the aquatic fauna are separately discussed, and in the end peculiarities exhibited by certain animals as a result of cavernicolous existence are described.

Preliminary note on the mode of infection of Earthworms by Monocystid parasites.—*By* B. L. BHATIA.

Nothing definite has hitherto been known concerning the mode of transmission of the spores of Monocystids from one earthworm to another. Schmidt (1854) and Minchin (1903) considered it possible that these spores pass out of the sperm-sacs of the worms with the sperms at copulation, and thus transferred to the spermathecae of another worm, and ultimately to the cocoon. But there was no record of their occurrence in either of these situations. The writer has found them in the spermatheca of *Pheretimæ barbadensis* (Beddard), and in two smears of the contents of cocoons of *Pheretimæ* sp., thus confirming by actual observation, the view considered plausible on *a priori* grounds by Schmidt and by Minchin.

On some new Cephaline Gregarines.—*By* B. L. BHATIA *and* SAM SETNA.

Preliminary observations on a number of new Gregarines were communicated by Mr. Setna last year. These have now been more fully worked out and described as—

Leidyana xylocopi, sp. nov., from *Xylocopa aestuans* (Linn.);
Leidyana leptoplani, sp. nov., from *Leptoplana*, sp.;
Caulocephalus crenulata, g. et sp. nov., from *Aulacophora*;
Loveicollis Kust.;
Gregarina oviceps Diesing, from *Gryllus* sp.; and
Leidyana gyllorum (Cuenot) Watson, from *Gryllus* sp.

Leidyana xylocopi is the first gregarine to be described from any Hymenopteran host, and *L. leptoplani* the first gregarine from a *Leptoplana*. The new genus *Caulocephalus* belongs to the family Gregarinadae, and is diagnosed as follows:—

Biassociative, satellite with a septum. Epimerite dilated at the anterior end like a cauliflower and narrower at the base. Protomerite with a characteristic specialised zone at its anterior end. Cysts dehiscing by a simple rupture. Spores ovoidal or spherical.

Notes on Intestinal Ciliate Protozoa of Frogs and Toads. —*By* AMAR NATH GHULATI.

Observations have been made on the following parasites arranged according to their hosts:—

I. *Rana tigrina* (Daud.).

1. Family Opalinidæ ..	*Opalina coracoidea.*
2. Family Bursaridæ ..	*Nyctotherus macropharyngeus* (Bezzen). *Balanatidium helenæ*, *B. elongatum*, *B. duedoni* and *B. gracile.*

II. *R. Cyanophylyctis* (Schneider).

1. Family Opalinidæ ..	*Opalina rananum* and *O. Coracoidea.*
2. Family Bursaridæ ..	*Nyctotherus macropharyngeus*, *B. duedoni* and *B. elongatum.*

III. *Rhexadactyla* (Lesson).

1. Family Opalinidæ ..	*Opalina lata.*
2. Family Bursaridæ ..	*Nyctotherus macropharyngeus*, *Balantidium helenæ*, and *B. duedoni.*

IV. *Bufo melanostictus* (Schneider).

1.	Family Opalinidæ ..	*Cepedea* (2 species).
2.	Family Bursaridæ ..	*Nyctotherus cordiformis* (Stein). *Balantidium* sp. ?

V. *Bufo macrotis* (Bouleng.).

1.	Family Opalinidæ ..	*Cepecler* sp. ?
2.	Family Bursaridæ ..	*Nyctotherus* sp. ?, *Balantidium* sp. ?

On some Tetraxonid Sponges in the collection of the Indian Museum, Calcutta.—*By* ANAND KUMAR.

The paper is based on an examination of Tetraxonid Sponges from Ganjam Coast, Waltair and Ramnad Coast around the Gulf of Mannar. Few species of sponges have, hitherto, been recorded from the northern region of the Bay of Bengal.

Nearly 286 species have so far been recorded from the Sea around the coast of India, of which no less than 205 are from the Gulf of Mannar and the coast of Ceylon. In the present paper 34 species are described, of which 8 are new to Science.

The following Genera have been dealt with :—

Ancorina, *Asteropus*, *Cinachyra*, *Paratetilla Discodermia*, *Histoderma*, *Chondrilla*, *Hmosphinopsis*, *Acanthella*. *Raspailia Clatheria*, *Gellius*, *Reniera*, *Pachychalina*, *Suberites*, *Spirastrella* and *Cliona*.

Wherever possible, as in the case of sponges from Waltair, colour varieties have been recorded, a notable instance of which is *Gellius Fibulatus* which assumes three different colour patterns.

An account of the alcyonaria of the Karachi coast with special reference to *Astromuricea ramosa* (Thomson).—*By* CH. ABDUL HAMID.

The work was commenced on 17 specimens of alcyonarians. In the middle of October, 1923, the author made a further collection of nearly 90 specimens from the same locality. A preliminary examination of the material revealed the presence of the following species:—

Sub Order Gorgonacea.

1.	Family Primnoidæ ..	*Echinomuricea Philippinensis.* *Echinomuricea Splendens.* *Echinomuricea Indica.* *Echinomuricea Andamanesis.* *Echinomuricea Flabellum.* *Echinogorgia Pseudasassapo.* *Astromuricea ramosa.*
2.	Family Plexuroidæ ..	*Plexauroides praelonga*, *Psammogorgia-ridleyi.*
3.	Gorgonidæ ..	*Lophogorgia Lutkeni.*
4.	Gorgonellidæ ..	*Verrucella flexuosa.*

Notes are added on the anatomy and histology of *Astromuricea ramosa.*

Preliminary Account of the Sea-anemones of the Karachi Coast, with special reference to *Paraphellia expansa.*—*By* BAWA BALWANT SINGH.

The material for study consists of about 500 specimens collected during the course of two visits to the Karachi coast. The specimens have been referred to the following genera :—

Family Paractidæ ..	*Actinostola* (Verrill and Stephenson). *Catadiomene* (Stephenson). *Stomphia* (Gosse, Stephenson).
Family Metrididæ ..	*Metridium* (Stephenson).
Family Chorioctidæ ..	*Choriactis* (McMurrich and Stephenson).
Family Chondractiniidæ ..	*Paraphellia expansa* (Haddon and Stephenson). *Actinange* (Verriil). *Leptoteichus* (Stephenson).
Family Actinoscyphidæ ..	*Paranthus* (Andres).

The author has devoted special attention to the study of the Anatomy and Histology of *Paraphellia expansa*.

A Preliminary Account of some Brackish Water Polychaetes from Madras.—*By* R. Gopalan.

This paper deals with a few polychaete worms from a piece of back water in Madras. The locality is subject to considerable influx of rain water during the rainy season The specimens collected belong to the Euryhyaline type. The following forms were collected and are described by the author :—

1. Ancistrosyllis sp.
2. Lycastis indica.
3. Nereis glandicincta.
4. Diopatra variabilis.
5. Marphysa sp.
6. Lumbriconereis sp.
7. Scoloplos sp.
8. Heteromastus sp.
9. A capitellid.

Of these Lycastis indica, Nereis glandicincta and Diopatra variabilis have already been described by Dr. Southern.

The other forms appear to be new to Science. The habits of the worms, in some cases, are also given.

On the so-called "pharyngeal nephridia" of Earthworms."—*By* K. N. Bahl.

The question as to whether the pharyngeal nephridia are salivary or excretory in function is discussed and an account is given of various experiments made to settle this question.

The Mitochondria and Golgi Apparatus in the Germ Cells and Somatic Cells of Tubifex.—*By* H. R. Mehra.

Spermatogenesis.

(1) The testes is composed of a large number of spermatogonia of about the same size. Each spermatogonium contains a thin layer of cytoplasm surrounding the nucleus. The mitochondria in the form of minute granules lie in the cytoplasm nearer the nucleus than the periphery. The Golgi apparatus mainly represented by the Golgi element is small and lies eccentrically at one side of the nucleus in close association with it.

(2) No multinucleate cell in the testes or in the sperm sac as described by Calkins or Dixon are formed in the course of formation of a sperm morula.

(3) The spermatogonia separate from the testes in groups. Each group becomes converted into a morula of spermatocytes (1).

(4) Some degenerate spermatogonia are met with in the sperm sac.

(5) Spermatocytes I and II pass inwards superfluous cytoplasm which flows towards the centre of the morula and forms the blastophore. The mitochondria lie on the inner side of the spermatocytes forming the periphery of the blastophore.

(6) The chromosomes seen in the dividing cell are very large in number and dot like. No aster is formed. The plane of division is tangential to the radius of the blastophore.

(7) The Golgi apparatus in spermatocytes (I) lies to the outer or distal side of the nucleus, it is much larger than that in the spermatogonium. The Golgi bodies are fused to form a quadrangular wall surrounding the central archoplasm There may be seen besides the main apparatus 1–4 Golgi bodies closely applied to the nuclear membrane.

(8) The usual stages found in the sperm sac are the spermatogonia and spermatid morulae. Spermatocyte II morulae are very rarely seen.

(9) Spermatocytes I probably give rise to spermatids by more than two divisions. Spermatocytes II are much smaller than spermatocytes I. The Golgi bodies apparently in the form of rodlets are joined end to end forming a quadrangular wall surrounding the archoplasm. The Golgi rim thus formed at the distal end of the spermatocytes and spermatids presents a characteristic appearance as seen in a side view.

(10) The Mitochondria, which are prominent in the growing oocytes and various somatic cells present practically an inconspicuous appearance during the spermatogenesis probably on account of the small size of the male germ cells. The thin layer of cytoplasm surrounding the spermatid nucleus has a hyaline appearance.

(11) The number of spermatids in a morula is very large (about 60–80). In a spermatid the centriole lies at the distal end in the centre of the archoplasmic mass at the base of the axial filament. There is only one centriole present.

(12) The mitochondria do not take part in the constitution of a spermatozoon.

(13) The spermatid nucleus when fully developed into the filiform head of the spermatozoon still attached to the blastophore is slightly longer than that of the free spermatozoon such as is found in front of the seminal funnel, therefore an appreciable reduction in the length of the head after the spermatozoon separates from the blastophore takes place by a slight contraction.

(14) The acrosome is here a very small piece of the blastophore cytoplasm at the apical end of the spermatozoon; it is therefore not homologous to the acrosome of Molluscs, Insects or Mammals.

(15) The Golgi elements during spermateleosis undergo a peculiar change. They break up in small rodlets or granules, which move proximally to surround the metamorphosing nucleus, around which they form a Golgi cover. The position and form of the Golgi bodies in a spermatozoon is thus remarkably different from those already known in other animals.

(16) The part of the spermatophore representing the united heads of the spermatozoa is stained deep black with the Mann-Kopsch. This shows that the Golgi cover around the sperm head goes unchanged even after the spermatozoa are united to form a spermatophore.

(17) The "Apyrene" spermatids in Tubifex are described in various stages of development, but the 'Apyrene' spermatozoa have not been observed. The axial filament is absent in these spermatids and the Golgi cover is present They do not correspond to the atypical or giant sperms described by Dixon. The question of the significance of the giant spermatids or sperms is discussed.

Oogonesis.

(1) In the growing oocyte the mitochondria, Golgi apparatus and cytoplasm increase in bulk. The whole cytoplasm is filled with innumer-

able mitochondrial grains. The Golgi elements fused to form a dense mass lie around the nucleus; there are also found a large number of isolated crescent-shaped batonettes with a small amount of archoplasm distributed in the cytoplasm in an even manner. In the fully mature ovum instead of a fused mass around the nucleus, isolated Golgi elements, though closely placed, are found. The rudimentary Golgi apparatus of oogonium thus grows very much and by a process of fragmentation forms rodlets, which separate from their perinuclear position and are evenly distributed throughout the cytoplasm.

(3) Many complete ova are converted into yolk, their nuclei being sometimes left as degenerate products. The mitochondria first become loaded with some food substance and assume a dense appearance. Soon after the Golgi elements and possibly the cytoplasm fuse with them and take part in the formation of yolk discs. The yolk discs are stained yellow with the Mann-Kopsch and therefore do not contain any fat.

Somatic cells.

The mitochondria and Golgi apparatus are described in the spermathecal epithelial cells, epithelial cells of the alimentary canal and seminal funnel, and nervous tissue.

Discussion.

(1) Separate entity of the mitochondria and Golgi elements.
(2) The chemical composition of the mitochondria and Golgi elements.
(3) The probable function of these cytoplasmic organs.

The Prostate Gland and the Atrium in the Microdrili.—*By* H. R. MEHRA.

(1) The atrium in two species of the Naididae is described. The prostate in *Nais elinguis* covers the lumen of the vas deferens, in *Slavina punjabensis* it covers the atrium. The atrium is formed as an ectodermal invagination and always occupies a position at the end of a short vas deferens. The atrial epithelium in the sexually mature *Stylaria lucustris* and *Slavina punjabenis* is wiped by the prostatic secretion, which passes through it; it is really not composed of glandular cells as has been so far considered.

(2) The prostate cells in the Naididae may surround the atrium or the vas deferens or both. The cells appear to penetrate into the muscle fibres of the atrial wall in order to directly communicate with the atrial epithelium. They also become more or less completely changed in the late stage of sexual maturity into the secretion and lose their entity. The prostate cells are peritoneal in origin. The prostate may be absent or rudimentary in some species of the Naididae.

(3) The cytoplasm in the prostate cells is basophile as distinguished from the acidophile central part with the secretion, and in *Tubifex tubifex* during the advanced condition of the gland generally contains basophilous granules, which pass with the fibrillar secretion as secretory products into the atrium. The prostate cells in the advanced sexual condition lose their structure and do not show mitochondria.

(4) The atrial epithelium in all the species of the Tubificidae considered is not composed of gland cells. It is on account of the prostatic secretion, which passes through it into the atrial lumen that it degenerates and its cells lose their entity.

(5) The prostatic secretion in the Naididae and Tubificidae appears as a fluid of thick consistency. Its function is mainly to cement or unite sperms received in the atrium. It does not contain mucin, but in the sections of *Tubifex tubifex* prepared according to the Mann-Kopsch method the central conducting part and a portion of the atrial wall shows the presence of a large amount of fat mainly olein, or some lipoid substance which reduces osmium tetroxide after a prolonged treatment

and thus becomes deep black like the dictyosomes of the Golgi apparatus.

Periodicity in Sexual Reproduction in the Naidiadae, with Observations on the Concomitance of Sexual and Asexual Reproduction.—*By* H R. MEHRA.

(1) Sexual and asexual reproduction generally do not take place at the same time, but sometimes the development of sexual organs takes place in the specimens undergoing asexual reproduction. This fact was recorded also by some previous workers, such as Piguet, Michaelsen and Stephenson.

(2) Asexual reproduction takes place vigorously just before and even at the time when the sexual phase appears. The observations in England and India have been recorded by me in some species of the genera *Nais*, *Branchiodrilus*, *Slytaria* and *Slavina*.

(3) Sexual phase appears in all the specimens of a species at a particular time, the spring, early summer or the autumn months of the year. So strong is the tendency to develop genital organs at this time, once the sexual reproduction begins, that they appear even in the Zooids before they are detached.

(4) According to Piguet it is only the largest and the most vigorous specimens which take to sexual reproduction. Generally the specimens which develop sexual organs first are larger and stronger, but later when the sexual phase becomes more common, even the most slender and the smallest specimens possess well-developed genital organs.

(5) Sexual worms are very active at this time and swim about actively by wriggling movements, which in *Nais Elinguis*, *Nais Pectinata—var. inequalis* and *Slavina Punjabenis* are otherwise not so obvious. Ditlevsen also observed that the sexually ripe *Nais elinguis* as contrasted with those which are not sexual have a tendency to swim and this he attributes to a particular posture of the body due to the weight of sexual organs in water. I do not think that his view to explain the movements in the sexual worms is correct; even in the absence of these organs *Stylaria lacustris*, *Branchiodrilus hortensis*, several species of Dero and *Nais* move in the same way.

(6) Sexually ripe specimens lie or move about in swarms (larger numbers) corresponding to a similar condition in certain Polychaete worms.

(7) A review of the previous work to explain the factors responsible for periodicity in sexual reproduction is given.

(8) The periodical appearance of a sexual phase is attributable to certain meteorological conditions as well as to some inherent factors in a particular species. The sexual phase appears under favourable conditions at a fixed time of the year to guard against the impending unfavourable conditions, and does not vary in an artificial environment. Each individual species behaves in a different manner in respect to periodicity.

On a case of Blastogenesis in *Lampite mauritii* Kinbr., together with some observations on the mutual affinity of certain local genera of earthworms.—*By* M. S. MEHKRI *and* C. R. N. RAO.

The paper gives an account of the salient external characteristics of the bud in Lampite mauritii, together with notes on the anatomical relations of the parent and the off-shoot. Some explanations in regard to special features of morphology are also appended.

The second part deals with the views of Dr. Stephenson and

Dr. Michaelsen on the relationship and probable descent of the members of Octochaetinae, and lines of filiation are suggested on the basis of the authors' studies of this and the second sub-family Ocnerodrilinae.

Spermatogenesis of *Anadenus sp. novo*, from Dalhousie.—*By* D. BHATIA.

The genital gland is hermaphrodite, and is composed of large alveoli containing different stages of the developing germ cells and nurse cells. Each alveolus is lined by a layer of Germinal Epithelium and surrounded by a fibrous layer termed Ancel's layer. Germinal Epithelium consists of mitotically dividing cells with oval nuclei containing interconnected chromatin masses. Some of these nuclei become rounded, the chromatin masses losing their connections and form the Progerminative cells from which both male and female germ cells are derived. Male germ cells which are small, develop before the nurse cells and, in the resting condition, their nuclei are opaque and contain fine chromatin granules on a dense linin network; whilst the female germ cells are much larger and develop after the nurse cells and have large nuclei with chromatin deposited in thick lumps.

The male Progerminative cells get detached from the Germinal Epithelium and fall as Primary Spermatogonia into the lumen of the alveolus. From these develop Typical or Eupyrene and Atypical or Oligopyrene Spermatozoa.

Typic Spermatogenesis.—In the Primary Spermatogonia numerous mitochondria appear in the cytoplasm; in the nucleus the chromatin is evenly distributed. The chromatin granules become coalesced and compressed together to form beaded chromosomes and the cell divides into Secondary Spermatogonia. Siderophilus granule makes its appearance at this division. Secondary Spermatogonia lie in large 'nests.' As the nucleus of the Secondary Spermatogonium grows in size, it becomes detached from the nest to form the Primary Spermatocyte. During the prophase of the first maturation division the nucleus of the Primary Spermatocyte passes through the Leptotene, Zygotene, Pachytene and Diplotene stages. The univalents are connected at their ends in pairs and present the appearance of thick rings. These connections break and the 22 chromosomes arranging themselves on the Spindle, go to form the Secondary Spermatocytes. The latter immediately undergo the second maturation division and form Spermatids. In the cytoplasm of the Spermatid mitochondria—megamitochondria—become vesicular Nebenkern with four golgi rods, axial thread, and just behind the nucleus a cloud of fine mitochondria—micromitochondria—make their appearance. Mitochondria become arranged along the axial thread so as to form its sheath which becomes spirally thickened. A part of the nebenkern gives rise to Acrosome which, in the adult sperm, is conical and pointed. The head has the shape of a gram seed.

Atypic Spermatogenesis.—Primary Spermatogonium has a round nucleus with uniformly distributed chromatin granules and a nucleus. Mitochondria are ten large granules scattered in the cytoplasm. Spermatogonia do not undergo many divisions and give rise to Secondary Spermatogonia. Each of the latter has a comparatively small nucleus which is excentrically placed and contains one or two karyosomes. Mitochondria present a pentagonal arrangement. In the growth-stage cytoplasm enlarges. There are no maturation divisions. The acrosome is hooked and partly buried in the head which is larger than that of the typic sperm and oval in shape.

The function and development of dimorphic spermatozoa are discussed.

Respiration and Adaptation in the Indian Ampullariidae.—*By* B. PRASHAD.

The processes of respiration in the common Indian apple-snail—*Pachylabra globosa* (Swainson)—are described in detail, and a full review of the literature on the subject is included. As a comparetive study the methods of respiration in the hill stream species *Turbinicola saxea* (Reeve) are also described, and the condition compared with that in *P. globosa* and other Indian and extra-Indian species which occur in the plains. The structural modifications in the two genera are also discussed in detail.

Preliminary observations on the Metamorphosis observed in Wasp (*Polistes Hebraeus*).—*By* HARBHAGWAN DAS.

The yellow wasp, which is so common in Lahore, makes its appearance early in Spring Several specimens were collected and a study made of the external features and the internal anatomy, viz. digestive, respiratory, reproductive and nervous systems.

The nest is composed of chambers in which eggs are laid by the female wasp, one egg in each chamber.

The fully developed larva secretes material with which the opening of the chamber is closed. After about 80 hours the pupal period commences. During the pupal period, which extends over 9 days, the external features of the adult make their appearance; the wings however remain in a rudimentary condition till the 12th day, when the Imago emerges out of the pupal cuticle.

Over a hundred specimens of larvæ and pupæ, at different stages of growth, were collected.

Notes on the status of some parasitic *Hymenoptera* in South India.—*By* T. V. RAMAKRISHNA AYYAR.

The parasitic hymenoptera constitute a vast complex, in many respect far more remarkable than most other insects. Apart from the striking peculiarities in their general form and in the nature of their life-histories as parasites on other creatures—characters which in themselves might form absorbing themes of study for the pure scientist—their relations to other insects and to mankind give them a position of unique importance in the insect world. Their economic importance is based on the fact that many of them act as natural enemies of many insects which are injurious to cultivated crops and thereby check the rapid multiplication of such pests; in other words, they help man in controlling insect pests, often even without his knowledge. Well does Sharp remark in his classical volume on insects that " the parasitic hymenoptera is one of the most neglected of the great groups of insects though it is of greater economic importance to mankind than any other. In spite of this two-fold importance the study of the parasitic hymenoptera found in India has not till now engaged the serious attention it deserves from Zoologists, either from the purely scientific or the economic aspect. The writer of this paper has been paying some special attention to these insects for some time past, and in this paper his idea is to invite the attention of Entomologists to the importance of the study of these insects by very briefly describing the bionomics of a few of the common forms so far studied by him in S. India. Common forms belonging to the families Braconidae, Ichneumonidae, Evaniidae and Chalcidae so far noted from S. India are described with very brief notes on their host relations and pointing out the economic aspect in each case.

A gall-forming thrips in Calycopteris floribunda. Austrothrips Cochinchinensis.—*By* Y. RAMACHANDRA RAO.

The paper records the occurrence of a characteristic gall caused by Thrips on *Calycopteris floriibunda* at Talfparamba Farm on the West Coast. The galls are usually axillary in their position and bag-like in structure and disclose in their interior the presence of a large colony of Thrips in different stages of development. An examination of the incipient stages of the galls has led the writer to conclude that the gall in question is really a bud or shoot gall, in which the Thrips insinuates itself between the leaf rudiments and after reaching the growing point so attacks the meristematic tissues that, while the central part ceases to grow, the sides begin to lengthen and cause the formation of a pocket-like structure at the tip of the shoot.

These galls have also been found in Travancore and S. Kanara and probably occur throughout the West Coast.

The writer is indebted to Prof. H Karny of the Zoological Museum, Buitenzorg, for the determination of the Thrips.

A practical and simple method for rearing Tabanid larvae.—*By* P. V. ISAAC.

The methods advocated by previous workers are briefly reviewed and their disadvantages, chiefly that of the impossibility of following the larval growth through the different instars, are discussed. It has been found that, with some knowledge of the habits of the larva in nature and after examination of the tracheal system of the newly hatched larva. Tabanid larvae may be reared in small vessels with suitable material inside and their growth most critically followed.

The life-history of *Tabanus Crassus*, WLK., and the identity of the female of the species.—*By* P. V. ISAAC.

The eggs are laid in a mass on leaves overhanging water. The larvae are predaceous and are found in moist earth at the water edge. A Chalcid parasitises the eggs. This species has up to now only been known in the male form, but it is found, as a result of rearing both sexes from the same lot of eggs, that the female has been wrongly described as another species, *T. sanguineus*, WLK.

The number of moults in Tabanid larvae.—*By* P. V. ISAAC.

Hitherto no observation has been made on the actual number of moults undergone by Tabanid larvae. It is established that as a rule they pass through seven instars, each followed by a moult, and transform into the pupa after the seventh moult.

Syria melanaria, Muls—a predator on Coptosoma ostensum, Dist.—*By* T. V. SUBRAMANYAM.

Coptosoma ostensum, a Pentatomid bug has been noted to infest a particular Butea tree out of several in the College Arboretum during the past three years. Breeding among these bugs was also noted a lady bird beetle, *Syria melanaria*, Muls., the grubs of which were found preying on the nymphs of this bug.

Coccinellids are generally reputed to feed on Coccids, Aphids, Thrips, etc., but as far as the writer's knowledge goes there appears to be no record of a Coccinellid feeding on a Pentatomid bug.

This paper gives an account of the observations of the writer regarding the habits, life-history, etc., of the bug and more especially of the predator.

On the Genitalia of the male Lac-insect (*Tachardia lacca*, Kerr), with a note on its method of copulation.—*By* A. B. MISRA.

The generative system of the male lac-insect (*Tachardia lacca*, Kerr) consists of two testes, two seminal ducts and the common ductus ejaculotorius with the associated penis. Each testis is an elongated sac which anteriorly tapers considerably. Posteriorly the calibre of the testis increases considerably and the mature organ occupies a large portion of the body cavity in the hindmost segments. Each testes gives off a short efferent duct (vasa deferentia which, uniting with its fellow of the opposite side, forms the common ductus ejaculotorius. The ductus ejaculotorius traverses the last two segments of the body cavity and the entire length of the penis which is the essential copulatory apparatus.

When a female has been chosen for mating, the male makes a backward movement and with its last pair of legs it holds the anal tube while the second pair of legs are employed to grasp the female resmous cell and the first pair of legs serve for the leverage of the anterior part of the body. The penis is moved to and fro and inserted into the female genital opening. When the penis has been inserted into the female genital opening then lateral and antero-posterior movements are executed. The act of copulation occupies about 20–25 secs. and only in one instance I found the period to extend to 40 secs. The male seems to exercise some sort of selection because it does not mate with the females indiscriminately.

On certain local names of the fishes of the genus *Garra*.—*By* S. L. HORA.

Fishes of the genus *Garra* are known under several appropriate names in various parts of India and Burma. These names contain references to the habit of the fish, its form or to the morphological structure of the peculiar mental disc and snout. The species of the genus live in rapid-running water, where they cling to rocks and stones by means of their suctorial discs. The meanings of the local names are given and their significance explained with a list of all the vernacular names so far known from India and Burma.

Early stages in the development of *Cyprinidæ* and *Siluridæ* (Pisces).—*By* HAMID KHAN.

Eggs of *Labeo gonius*, *Labeo rohita*, *Cirrhina mirgala* and other Cyprinidæ, and of *Wallago attu* (Siluridæ) were collected from different spawning fields in the Punjab during the breeding seasons of 1922 and 1923. Their development in the living state was studied under the microscope and different stages preserved in various reagents for further work, which was carried on in the Zoology Laboratory of Government College, Lahore.

Eggs measure 1·5 mm. in diameter and each is invested with a gelatinous covering which swells to 3–4 mm. on falling in water. Eggs sink to the bottom and time of hatching varies from 20 to 40 hours. A newly hatched embryo is devoid of pigment. In *Wallago attu* the head of the embryo, just before hatching, has at its anterior end three pairs of lobular projections which later on develop into barbels. Heart is bent upon yolksac and yolk circulation before and just after hatching is simpler than in Ophiocephalidæ. In Cyprinidæ yolk sac is an oval shaped bag curiously prolonged posteriorly and extending upto the anal invagination. In *Wallago attu* as in *Ophiocephalus marulius*, it is round and does not extend to the end of the gut.

Eyes, in the 2nd-day embryo, are completely pigmented. External gills and arches are visible and mouth opens for respiration. Pectoral fins appear as buds but soon elongate to help the small fry to move about in the little pools in which they are kept by the parents. Some of the segmental vessels carry blood from, and others pour into, the aorta. Their circulation is not systematic. At the posterior end, on the ventral surface near the junction of dorsal aorta and caudal vein, there is a system of lacunar vessels which, near the anus, unite to form the caudal vessel. The latter continues forward as the Subintestinal vein. This vessel receives branches from the yolk sac. In the hinder part of the posterior cardinal the blood flows in the opposite direction and this fact has been observed by me in *Ophiocephalus marulius* and by Willey in *Ophiocephalus striatus* also.

On the 3rd day yolk is absorbed completely. Gut opens to the exterior and air sacs appear as appendages of the gut on the dorsal surface. *Wallago attu* fry are so predaceous that they begin to devour each other. A *Wallago attu* fry of 8 days measures 20 mm. and of other species 7 to 8 mm. only.

Dorsal fin becomes marked off from the embryonic fin on the 13th day and is completely separated off on the 17th day with 9 distinct rays. Caudal fin is constricted off dorsally on the 17th day but is still continuous ventrally with the embryonic fin and becomes separated off totally on the 21st day. On the 17th day one row of scales appear on the dorsal surface, as tile-like coverings, in Cyprinidæ.

The fin rays make their appearance on the 8th day on the ventral surface below the posterior end of the notochord and are preceded by the formation of a Capillary plexus. Then the bend of the notochord carries the development of the rays to the dorsal surface and the tail fin becomes bilobed; but the dorsal lobe is without rays and is later on displaced by the excessive growth of the ventral portion. Thus the whole of the caudal fin skeleton is formed by the formation of the rays on the ventral surface of the notochord.

On the Occurrence of Oocytes in the testes of *Rana tigrina* and the Phenomenon of Iso-agglutination.—*By* B. S. RAMANNA, *and* C. R. NARAYANA RAO.

The relation of the organ of Bidder and occurrence of Ovum-like bodies in the testes of anurous amphibians are examined with a statement of the views of the previous investigators on hermaphroditism in amphibians. The causes leading to the formation of Oocytes are examined and the influence of these bodies on the sperms in activating them to swarm into three dimensional pin-wheels is investigated. The occurrence of atypical sperms has been noticed for the first time in the frogs and they like the typical sperms, are observed to come under the agglutination influence of the Oocytes.

On the Segmentation Cavity of the egg of some frogs together with some observations on the modification of the structure of the skin and stomach of a new genus of Engystomatidas.—*By* B. S. RAMANNA *and* C. R. NARAYAN RAO.

The supposed segmentation cavity of the egg of the frog is really the anterior division of the enteron and is the first to appear. It is termed the fore gut in contrast with the mesenteron which gives rise to the mid-gut and might be distinguished as the noto-enteron in preference to neurenteron suggested by Dr. Meek, in view of the fact that the chorda dorsalis is differentiated much earlier than the formation of the neurenteric passage. A third cavity presumably a derivative of the fore-gut gives rise, by fusion with the posterior end of the mesenteron, to the allantois or the bladder of adult. The central point of, interest is that the mesenteron arises as a split in the yolk cells instead of as is commonly supposed, through invagination. The yolk plug resolves into mesoderm, while the proliferating epiblast cells at the blastopore give rise to the mesenchyme.

The adult anatomy of the new frog shows non-ossification of the sphenethmoid, the persistence of the trabeculae, a large serous space between the sclerotic and the choroid, the fusion of the extrahyals, the incomplete auricular septum and other features of modifications of the skin and stomach, which latter forms an interesting case of convergence due to identical habits of taking into the alimentary system, fine earth by certain oligochaete worms end the new engystomatid frog.

On the alleged flow of blood from the Renal Portal to the Hepatic Portal system in *Varanus bengalensis.—By* C. John.

Thapar and Bhattacharya describe the presence of a connection between the renal portal and the hepatic portal systems and conclude that most of the blood from the posterior portion of the body flows into the hepatic portal and not into the renal portal. This conclusion is highly questionable as the present writer has discovered certain valves in the aforesaid connection which prevent the flow from the renal portal to the hepatic portal, and allowing a flow in the opposite direction. If there is such a flow from the hepatic portal to the renal portal, it is quite a unique and so far unrecorded phenomenon.

Section of Botany.

President:—PROF. S. P. AGHARKAR, M.A., PH.D., F.L.S.

Presidential Address.

THE STUDY OF VEGETATION OR PLANT SOCIOLOGY.

1. *Introduction.*

By the "study of vegetation" is understood the study of plant-communities as distinguished from the study of the individual species composing these. This is a branch of Botany of comparatively recent growth, though its beginnings can be traced to very old times. Its real development dates from the publication of Warming's epoch-making work, the "Plantesamfund" in 1897.

The principal countries where synecological research is at present being actively pursued are the United States of America, Switzerland, the Scandinavian countries, France, England, Germany and Austria, the first four having perhaps made the largest contributions.

In India also increasing attention is being paid to the subject, as evidenced by recent publications. Dudgeon, in his Presidential Address to this section in 1922, gave an account of these, and among more recent contributions may be mentioned those by Osmaston (1922), Miss Hartog (1923), and Dudley-Stamp and Lord (1923).

We are, however, as yet in the descriptive stage of the study of Indian vegetation, which has not been adequately described for any part of India. We have also not begun to make use of the refined analytical methods recently developed in Europe.

I therefore thought that it might be useful to some of my co-workers if I attempted in my address today a short resumé of recent work on some aspects of the subject and I crave your indulgence and patience in listening to me.

Since plants are usually found occurring together we can not hope to get a deep insight into their ecology unless we recognise them as members of the communities in which they naturally grow. The "ideal" method for such studies might be, as Tansley (1923) says, "to study each species separately, till we knew details about its life-history, the manner of its dispersal, its relations to the varying conditions of climate and soil, and then proceed to study the species as it exists in communities along with other species."

It is, however, not necessary to wait until such work is accomplished, before beginning to study the plant communities themselves. There are many problems about the communities which we can find out before we possess a detailed knowledge of the Autecology of the individual species composing them. Such a study invariably forces us to study the individual species and to recognise the fact of our inadequate knowledge about it. It is, therefore, not at all illogical if we start with a consideration of the unit Plant Community—the Plant-Association.

2. *The Plant-Association*

The term Association was orignially used by Humboldt (1807) in the sense of "Plantes associées." It was used by different authors to designate communities of various types, but it has, within recent years, acquired a more definite meaning. At the Brussels Congress of Botanists (1910) the following definition was adopted by a majority of votes: "An association is a plant community of *definite floristic composition*, presenting a uniform physiognomy and growing in uniform habitat conditions. The association is the fundamental unit of Synecology" (Flahault and Schröter, 1910). The association as here defined corresponds very much to the Consociation of Clements (1916) in so far as it is a climax community.

Du Reitz, Fries and Tengwall (1918) propose elimination of the habitat idea from this definition on the ground that the association being a vegetation-unit, naturally defined by certain inherent characteristics of form and structure, any attempt to introduce the habitat in defining it is departing from the facts presented by the vegetation and considering the causes of these facts.

Tansley (1920) considers the definition as by no means complete owing to the possibility of applying it equally well to smaller units within the association, such as a "plant society." He recommends enlarging it by including the conception of *maturity* and *stability*, thus imparting increased integration and individuality to the idea of the fundamental unit. He is in favour of restricting the use of the term Association to a "climax" community, the corresponding temporary or developmental communities being referred to as "associées." In this he is following Clements Tansley, however, does not agree with Clements in restricting "the association" to climax communities determined by the climate but is also inclined to include in his definition such stabilised communities, "having all the characters of associations, which are not climatic climaxes and show no clear signs of developing into them." Nichols (1923) is in favour of giving the term association to any community of associational rank, regardless of its developmental relations, since otherwise "it is impossible to refer definitely to any such community until its developmental rank is determined."

Braun-Blanquet (1921) also considers the definition of Flahault and Schröter "vague and capable of various interpretations" and therefore not suitable for the worker in the field who must have a more precise one. He defines (loc. cit.) the association as a plant-community with definite floristic and sociological (organic) characters revealing a certain independence through the presence of "characteristic species" which he defines as exclusive, almost exclusive, or at least mainly found in that association corresponding to grades 5, 4 and 3 of his scale of exclusiveness.

Tansley (1922) in his review of Braun's work points out that in English the phrase "characteristic species" is hardly confined to species showing the three higher grades of exclusiveness, but is also employed to those showing a high degree of constancy. English writers only recognise a species as "absolutely characteristic" if it shows both the highest grades of constancy and exclusiveness, "very characteristic" if it shows a somewhat lower but still a high grade of each. This, however, is no reason against the acceptance of Braun's views regarding characteristic species. In fact we see that Tansley in his Practical Plant Ecology (1923), p. 31, has accepted these.

Du Rietz (1923) considers Braun's definition of characteristic species as vague. He does not think it would be possible to find "characteristic species" for every association in spite of the vague use of the term. Frey (1921) pointed this out in the case of the Alps. Du Rietz is of opinion that for Scandinavia at least the acceptance of this criterion would lead to the union of a number of associations in an unnatural assemblage without the slightest floristic identity.

Nichols (1923) has very recently defined association as a piece of vegetation "essentially similar throughout its extent in physiognomy, in ecological structure and in floristic composition." By physiognomy of a plant community he understands "its general outward appearance—its external morphology, so to speak." He includes under "ecological structure all peculiarities in vegetation which are of ecological significance, while physiognomy represents but one phase of ecological structure." His idea of ecological structure is thus much more comprehensive than that of physiognomy as it takes into consideration various "peculiarities of the vegetation which do not express themselves visibly through life-form, as well as those that do so," such as for example the behaviour of the constituent plants in relation to various conditions of light, temperature and atmospheric humidity, or to various water and other conditions in the soil. "Whereas physiognomy would take no account of the various shrubby and herbaceous elements within a forest association, these would be included under ecological structure. Ecological structure is thus to the plant community what morphological and physiological structure are to the plant."

I consider Nichols to be justified in thus eliminating the idea of the habitat from the definition of the association for the reasons stated and in including ecological structure as distinguished from physiognòmy in the definition. It must, however, be pointed out that Flahault and Schröter (1910) understand physiognomy in a wider sense than Nichols, as is seen from Remark 5 attached to the definition of association, which is as follows: "The physiognomy of an association is determined by the relative abundance of the various growth forms of which it is composed."

Whether association should be used in an abstract or concrete sense has caused some difference of opinion. There seems to be a considerable body of opinion in favour of Nichol's recent proposal to use the term in both the senses according to the context. Nichols is of opinion that such a double use of the term is not likely to cause confusion, the use of the "species" concept in both an abstract and a concrete sense offering very good parallel to it.

Whether the plant association is an organic entity has been very much debated. Whereas according to Clements the association is an organism having all the characters of growth, development, maturity and reproduction, others like Du Rietz and Gams deny this. Tansley (1920) has discussed this question critically and the majority of workers have now accepted his conclusion that the association is a quasi-organism or organic entity, "being composed of organic units, which behave in many respects as a whole and therefore have to be studied as a whole." From these correspondences it derives its similarities to organisms, while its differences are derived from the general independence of the organic units of which it is composed. It must, however, be pointed out that this concept is only applicable to the association-concrete and not to the association-abstract which can, in such cases, be referred to as the association-type.[1]

3. *The Structure or Morphology of the Association.*

The intensive study of the association or the morphology of the individual plant community has been mainly developed by Scandinavian botanists on statistical lines, among whom Raunkiär is the most eminent, and more recently by Braun, Du Rietz, Arrhenius and others. The history of the morphology of the association up to 1920 has been ably dealt with by Rübel, who has also given a short resumé, with references to literature, of the various methods used for determining the mutual relationships of the various species composing it. More recently Messrs. Braun-Blanquet and Pavillard (1922) have published a very useful vocabulary of the subject in the French and German languages. Tansley (1922) in his review of this publication has supplied English equivalents wherever necessary and thus done a great service to English-speaking synecologists. I propose to confine my remarks to the concepts as introduced by these authors, together with some not expressly included by them.

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[1] This association-type differs in certain respects from the association-type of Nichols referred to later on.

The first procedure in studying a plant community is to note *all* the plant species occurring in it. After making this "floristic list in the field" we have to determine the importance of each species in a population or the particular example of the association studied, either due to its growth-form or the number of its individuals. We thus determine in various ways, into the details of which I do not propose to enter :—

(1) *Abundance or frequency*—which is the expression of the relative numbers of each species entering into the constitution of the population or the particular example of the association studied.

(2) *Dominance:* In closed vegetation, where the ground is continuously covered or continuously shaded by a plant, the association is found to have one or usually more *dominant species*, which mainly determine the external appearance or physiognomy of the association. This physiognomy is primarily determined by the life-form of the dominants. Thus the Sundri (*Heretiera minor*) and the Gengwa (*Exoccearia agllocha*) which are the principal dominants of the Sundri forest in the Sundribans, the Sal (*Shorea robusta*) which is one of the principal dominants of the Sal forests of India, the various Rizophores together with palms like the Nipa, which form the principal dominants of the mangrove formation of the Ganges Delta, determine the physiognomy of the association in which they respectively occur. The presence of the dominants strongly influences and determines the rest of the species occurring in the association, partly because of these others growing in the shade of the dominants or partly because the growth of the dominants produces a special kind of soil or otherwise reacts on it.

Although English and American authors use the term "Dominance" in the above sense of having a prepondering influence over the other members of the association, Messrs. Braun-Blanquet and Pavillard assign a more extensive connotation to it. They understand by it "the extent (volume or surface) occupied or covered by each species," and recognise five grades of dominance. Thus even a subordinate species has its dominance grade. The term is not applied by English authors to the lower grades of dominance of these authors.

(3) *Distribution*—which is the manner in which the indivi-

duals of each species are distributed in the population or example of the association studied (uniformly or not).

These three characters can be expressed by numbers representing degrees in a scale of 5. They are usually calculated by counting the individuals of each species in a number of small squares, distributed uniformly within the population or the particular example of the association studied, this example being as typical of the association as possible. Messrs. Braun-Blanquet and Pavillard have further drawn attention to various minor sociological characters such as—

(4) *Sociability*—by which is understood the disposition of individuals in the interior of an association. *Five* grades are distinguished of which grades 5, 4 correspond to the conception of the "society" and grades 3, 2 correspond to "clan" of English and American authors.

(5) *Vitality* or *prosperity:* Four states are recognised in which individuals are (i) well developed, and complete cycle of development is regularly accomplished, (ii) cycle of development usually incomplete, showing vigorous vegetative development, (iii) cycle of development usually incomplete showing restricted vegetative development and (iv) germinating accidentally, not usually multiplying.

(6) *Periodicity:* The study of this allows one to fix the duration and to estimate the intensity of the competition of each species; also to establish "seasonal aspects" to which correspond seasonal changes in the physiognomy of the community.

This would correspond to a certain extent to the concept of "Mixed formations in time" as recently proposed by Saxton.

(7) The *dynamic behaviour* of each species in regard to the community as a whole. The following grades of behaviour with a symbol attached to each are recognised: constructive, maintaining, fixing or consolidating, neutral, destructive. These terms, however, have not as yet come into general use.

All the above characters belonging to the species composing an association are analytical and determined by direct observation in the field. Apart from these the species of an association exhibit some characters, which are determined by a comparative study of numerous examples of the association. These are known as the synthetic characters of the association. They are—

(8) *Constancy*—which is determined according to the presence or absence of a species in all the examples of an association studied. Raunkiar's method of Valence is perhaps of the greatest usefulness, though Arrhenius has recently proposed a modification of it.

Some species are found with great regularity in all or nearly all samples examined; others are wanting in a smaller or larger number of samples. Five degrees of constancy are thus recognised : Those occurring in 100% – 80% of examples studied = 5, 80% – 60% = 4, 60% – 40% = 3, less than 40% without being very rare = 2, very rare (accidental) = 1.

Species showing constancy 5 may be called CONSTANTS. According and Du Rietz and the Scandinavian workers this term should be restricted to species with a constancy of 90% and above.

(9) *Exclusiveness* or *Fidelity*—which is the measure in which species are confined to certain communities. Five degrees of exclusiveness are recognised by Messrs. Braun-Blanquet and Pavillard.

(*a*) *Characteristic Species.*

Exclusives, almost or quite confined to certain communities = 5.

Electives, found especially in a given community but also (rarely) in related communities = 4.

Preferring a given community to others, though occurring more or less abundantly in these = 3.

(*b*) *Accessory Species.*

Indifferants, more or less abundant in many diverse communities = 2.

(*c*) *Accidental Species.*

Foreign, species accidentally introduced = 1.

One conception which does not find a place in the above scheme but has been extensively used in England and America is that of the " Consociation."

The community formed by a single dominant species of an association to the exclusion of the others is called a consociation. Clements (1916) defines it as follows : " Whereas an association is actually a grouping, the consociation is pure dominance." This uniform dominance makes its recognition a simple matter.

Thus in the SUNDRI-GENGWA association above referred to, both the species are co-dominant in the central and northern parts of the Sundribuns. As we pass southwards Sundri diminishes in frequency while Gengwa remains, till at length the forests become almost pure Gengwa. This latter may be cited as an example of a consociation. The separation of the two dominants is due to the indifference of Gengwa to the presence of salts in the soil whereas Sundri is very susceptible to these. This same habitat factor is responsible for certain other differences in the ground vegetation of these two consociations, but these are never so pronounced as to suffice for differentiating the Gengwa forest as a separate association.

Another instance of the same sort is provided by the distribution of the mangrove forests in the Sundribuns. The RHIZOPHORS are plentiful near the coast, but some of them--

particularly GORIA (*Kandellia rheedii*)—GORAN (*Ceriops roxburghiana*) and KANKRA (*Bruguiera gymnorhiza*) are to be found naturally on the banks of the larger rivers even up to the northern boundary of the forests (Prain). The determining factor in this case also is the susceptibility of the Rhizophors, and the indifference of the others to the varying degrees of salinity of the soil solutions in which these are found. We thus have a Rhizophora consociation in Betmar Gang and other places, a Kandellia consociation in Aruabari Khal and so on.

Society.

Another concept not dealt with (though included under sociability) by Braun-Blanquet and Pavillard is that of a Plant society By society is understood a community of lower rank formed by certain gregarious subordinate species within an association or consociation. "The society is a localised or recurring dominance within a dominance" (Clements, 1916).

"The society comes next below the consociation in rank but it is not necessarily a division of it," for the same society may extend through or recur in two or more consociations, i.e. throughout the entire association.

A society has usually a single dominant, which may occupy the ground to the exclusion of the association-dominants. This is due to the fact that the society-dominant occurs only where there is some local difference in the habitat, or its presence may produce new local conditions leading to great abundance of the subordinate species.

4. *Systematic Grouping of Plant Communities or the Classification of Vegetation.*

No general agreement has yet been reached as regards the classification of vegetation. Floristics, Life-form or Physiognomy and Habitat have all been used singly or in combination by various authors as the basis of classification, but as yet no satisfactory system has been evolved. Among those that have been proposed that of Warming (1909) as revised by Warming-Graebner (1914-18) based mainly on habitat and physiognomy has perhaps obtained the widest currency owing to its distinguished author having tried to fit the vegetation of the whole world within his scheme. Other systems are those of Brockmann-Jerosch and Rübel (1912), and Clements (1916) while Du Rietz and his collaborators proposed an outline in 1918.

Tansley (1920) in a very illuminating article has critically reviewed all these systems and pointed out the causes for these divergences of opinion. He comes to the conclusion that "each of these possible bases of classification proves inadequate—a *cul de sac* which cannot lead us to a natural classification of vegetation, and *we are driven back to the vegetation itself, from which we ought to have started, as the only possible basis.*" It is interesting to note that this view as to the vegetation forming the only basis of classification has found wide acceptance and we can, therefore, hope to have within reasonable time some general agreement among synecologists on the subject. Recognising the necessity of having a higher natural unit than the association for grouping the associations he comes to define the *Formation* as "the sum total of the vegetation which is naturally grouped round the association including developmental and degenerative phases and alternative developments due to accidental or historic causes."

As Formations in the field he recognises the following:—

"*Firstly*, those sharply limited natural units, in which the correspondence of habitat with a definite set of plant communities is clear and unmistakable, such as salt-marsh, "Hochmoor" and fen formations Here the common name of the formation is derived from the *habitat* or from habitat and vegetation together."

"*Secondly* formations such as the heath formation in England, which are partly determined by edaphic and partly by climatic factors. Here the common name is derived from the vegetation."

Lastly climatic formations, such as the summer deciduous forests of England, which are unable to develop on certain soils or under local topographic or climatic conditions. Here the common name is again derived from the vegetation.

Recognising development of vegetation as a concrete fact equally with its structure, he is still not willing to use it as a basis for grouping plant communities. In fact if "only mature and stable communities are recognised as associations, the idea of development cannot be brought in as a basis of classification.

Braun-Blanquet (1921) considers that a natural classification of plant communities will only become possible when the fundamental units, "the associations" are better known. He considers that the recognition of "clearly understood, easily delimitable, easily distinguishable units of associations" will alone form the scientifically unobjectionable basis for a system of Plant Communities." While agreeing with Tansley's contention that the classification of plant communities must be based on the totality of characters presented by these, he points to our comparative ignorance of these characters and also to the fact that no effort has yet been made to determine their relative systematic value. It has also to be remembered that not every piece of vegetation or plant aggregate can always be assigned to any particular association, owing to the presence of numerous mixed types and incompletely characterised stages of development and degeneration. He is of opinion that under these circumstances a system of plant communities based on their floristic composition rests upon a surer basis, as it is mainly through these and their assemblages that the most important characters of the association are expressed. These characters are of two kinds, *firstly*, those that are of high sociological but small diagnostic value, like the dynamic behaviour of the species, and *secondly*, those that are of small sociological and high diagnostic value such as "exclusiveness." As these characters have already been dealt with under the morphology of the association I will not repeat them once more.

Associations which are precisely delimited by the characters aforementioned are united into *groups of Associations.* The relationships of associations thus grouped together are expressed by the characteristic species occurring exclusively in an association-group. The association-groups could be named in various ways Braun-Blanquet recommends the use of the suffix *-ion* to the name of the genus or species of the most widely distributed association of the group.

The delimitation of the association-group is not always a very easy matter. Braun considers his scheme has the advantage of very wide applicability over the Anglo-American proposal to unite *developmental series* into a natural unit as also over the proposal of the Swedish workers to base such units on only "natural" units.

Braun considers it premature to unite the "association groups" into higher categories until a sufficiently large number of these should be adequately known.

At the end of his paper Braun gives an example of grouping the plant communities according to their *sociological progression* by which he understands the degree of organization exhibited by them. At the lowest rung of the ladder are the sociologically most primitive in-constant (loose) floating protist societies of the air and water where the organic connection of parts is very loose. At the highest step in the ladder is to be placed the tropical rain-forest, an example of the highest possible plant-sociological development. The fixing of the relative position of the intermediate communities, is, however, likely to be a troublesome affair.

Nichols (1923) has very recently published a very interesting paper in which he suggests a generalised scheme to be used as "A working basis for the ecological classification of Plant Communities." The ecological classification of plant communities consists in the arrangement into common groups of different associations which are related to one another by environment. These groups represent *ecological vegetation-units* of a higher order than the association.

In accordance with the three different ways in which the influence of environment on vegetation may be expressed, he proposes *a three-fold classification* based on each. Thus the association in its ecological characteristics being the result of the action of the environment on its constituent species, physiognomy and ecological structure forms one of the basis of classification. Secondly the influence of environment being seen in the manner in which plant associations are distributed over the face of the earth in relation to various features of climate and physiography, the geographic relations furnish another basis of classification. Thirdly the influence of environment being seen in the changes in vegetation which ensue in course of time, their successional relationships offer a third basis for classifying plant communities. The three branches of plant sociology may thus be distinguished as: (1) Physiographic Plant Sociology, (2) Geographic Plant Sociology and (3) Dynamic Plant Sociology.

Taking physiognomy and ecological structure as the basis of classification "all associations which resemble one another in physiognomy and ecological structure, *regardless of their floristic composition*" can be united into a common "*association type.*"

The association-types thus derived are named in terms of physiognomy and ecological structure. Thus the various associations of lakes and swamps can be grouped under such categories as submerged leaf association-type, floating-leaf-type, reed-swamp type, etc.

The association type or formation has been used as the basis of ecological classification by Warming (1909), Brockmann and Rübel (1912), and Raunkiär (1918).

Considering the way in which associations are grouped into geographically defined complexes, Nichols comes to recognise *Climatic Unit-areas* and *Physiographic Unit-areas* to which correspond *Climatic Plant Formations* and *Physiographic Plant Formations* respectively. Any portion of the earth's surface which is characterised by having essentially the same kind of climate throughout and whose boundaries are determined by climate may be designated a *Climatic Unit-area.* The vegetation of any specific climatic unit-area taken in its entirety, may be designated a *climatic formation*. It comprises a complex of associations which are geographically linked with one another by climate. In spite of this heterogeneity, however, there is the unmistakable tendency, through the phenomena of succession, for vegetation to progress toward a condition of ecological uniformity, i.e. towards a climatic climax association-type. Tansley objects to treating the whole of the vegetation within a climatic region as a climatic formation on the ground that nothing like a sharp line can be drawn between one climatic region and another, so that it becomes impossible to delimit climatic formations in Nichol's sense.

The term *physiolographic unit-area* is applied to the larger and more outstanding features in the physiography of a region, such as ravines, valleys and flood-plains, rocky uplands, and plains, lakes, bogs, etc., which are the primary causes of the differences in vegetation in regions with a uniform climate.

A *physiographic unit-area*, like its climatic counter-part, tends to exhibit more or less pronounced uniformity of a sort; there are certain habitat conditions which prevail throughout the entire area. Thus a lake is characterised by the presence of water: a salt marsh by the presence of salt water; a ravine by its relatively high atmospheric humidity and by its protection from sun and so on. At the same time there is considerable local diversity of habitat, such for example, as that afforded by dry cliffs, moist slopes, the wet ledges, the inundated rocks, etc., in a ravine.

The vegetation of any specific physiographic unit-area taken in its entirety may be designated a *physiographic formation;* it comprises a complex of associations which are geographically linked with one another by physiography, e.g. a rock ravine formation, a salt-marsh formation, etc.

Like a climatic formation a physiographic formation may be a very heterogeneous vegetation-unit. Here also there is a tendency for the vegetation to progress towards a common climax, the nature of which, in so far as it differs from the climatic climax, is primarily determined by the habitat conditions characterising the area as a whole.

The climatic formation and the physiographic formation as thus defined represent ecological units of a higher order than the association. The climatic formation is the more comprehensive unit and a particular climatic formation ordinarily includes numerous physiographic formations.

Considered from the standpoint of their successional relationships, associations can be grouped into *successional series or seres*, by which we understand a series of associations taken collectively which follow one another on any given area of the earth's surface and in the course of time. Of the various associations in such a developmental series, only the climax can be regarded as permanent in character. All the others are temporary; they are destined in the course of succession to be superseded by the climax or by an association more nearly approximating the climax type.

Recognising that every individual association is a member of a particular developmental series the dynamic classification of plant communities has to do fundamentally (1) with the relation of the individual association to the climax of its particular series and (2) with the recognition and co-ordination of different types of succession in their relation to cause, trend, orgin and climax.

From the causational standpoint, three types of succession are commonly distinguished, viz., *biotic, topographic* or *physiographic* and *climatic*. These are brought about by plant and animal agencies, changes in physiography and changes in climate respectively. To these Nichols adds *anthropeic* and *pyric* where succession is brought about through the influence of fire.

In relation to trend succession may be progressive or retrogressive. *Progressive succession* may aptly be described as succession towards a climax and *retrogressive succession* as away from a climax. Of the various types of succession distinguished above with reference to cause, biotic succession is typically progressive. Physiographic succession may be either progressive, retrogressive (when the habitat is adversely affected by the changed conditions) or cataclysmic (when the habitat is detroyed as by erosion, e.g the erosion of river banks in the sundribans leading to destruction of forests). Climatic succession may be either progressive or retrogressive; it may even be cataclysmic. Pyric succession is invariably retrogressive; most commonly it is cataclysmic. Anthropeic succession is likewise primarily retrogressive and commonly cataclysmic; but man himself purposely may inaugurate secondary successions of a progressive character (e.g. changes introduced by the forester through his application of ecological principles in silvicultural practice), etc.

Considering succession in relation to orgin, three types of series can be distinguished according to the nature of the area in which succession takes place. Three series are known as *Xerarch*, and *Hydrarch* (suggested by Cooper) and *Mesarch* (suggested by Nichols).

Xerarch series are those which "having their origin in Xerophytic habitats, such as rock shores, beaches and cliffs, become more and more mesophytic in their successive stages." *Hydrarch* series are "those which originating in hydrophytic habitats such as lakes and ponds, also progress towards mesophytism" or toward a developmentally more advanced condition. *Mesarch* series are "those which originate in mesophytic habitats, such as are afforded by moist, rich soils, and in which the vegetation likewise becomes progressively more and more advanced as a result of development. The advance here may take the form, more especially, of increasing complexity."

Succession in relation to climax. The climax attainable in any area is largely determined by the geographical conditions—by climate on the one hand and by physiography on the other. As Nichols says geograpical conditions tend to act as limiting factors to prevent development from progressing beyond a certain stage, e.g. climatic conditions prevent the attainment of mesophytic forest climax in a desert region; physiographic conditions prevent its being attained in saline situations along the sea-coast. We thus come to recognise two kinds of climax in any given area determined largely by the geographic conditions.

A climatic climax is one determined by climate. It is the most advanced type of association that can be developed under the given climatic conditions characterising a climatic region.

A physiographic-climax is one determined by physiography. It is the most advanced type of association that is capable of development in any physiologically uniform area, e.g. in a rock ravine, the moist banks, the dry cliffs, and the wet ledges would each be characterised by a different climax on account of their physiographic dissimilarity.

In studying vegetation from either the point of view of physiognomy and ecological structure or that of its geographical distribution, we consider it as a physically existent and concrete reality. Roughly speaking we consider only features which might be plotted on a vegetational map. From the point of view of succession, however, we regard the associations of the present day as being but stages of development; they are the products of past development and serve as starting points of future development.

The three points of view above outlined have each been used as a rational basis for ecological classification. "No scheme for the classification of plant communities can be regarded as complete however, which fails to take into consideration all three."

Nichols then proceeds to point out by a concrete example how the three points of view could be combined into one in practice. He has used this scheme in the classification of the plant associations of northern Cape-Breton Island (1918) which with a few modifications he makes (1923) is as follows :—

I. The climatic climax association-type : the climax forest.
II. The physiographic formation-climax of the region.
  A. The primary formations of xerarch and mesarch successional series.
    1. The formations of ordinary well drained uplands.
      (*a*) The association types of rock outcrops.
      (*b*) The association types of talus.
      (*c*) The association types of glacial till.
      (*d*) The association types of sand plains.
    2. The formations of well drained uplands along streams.
      (*a*) The association types of rock ravines.
      (*b*) The association types of clay ravines.
      (*c*) The association types of open valleys.
      (*d*) The association types of boulder plains
      (*e*) The association types of flood plains.
    3. The formations of well-drained uplands along the sea-coast.

(*a*) The association types of bluffs and headlands.
(*b*) The association types of beaches and dunes.

B. The secondary formations of xerarch and mesarch successional series.
  1. Formations due to influence of lumbering.
  2. Formations due to the influence of fire.
  3. Formations due to the influence of cultivation

C. The primary formations of hydrarch successional series.
  1. The formations of inland lakes and ponds.
    (*a*) The association types of well drained lakes.
    (*b*) The association types of undrained lakes
  2. The formations of inland lake and seepage swamps.
    (*a*) The association types of well drained swamps
    (*b*) The association types of poorly drained swamps.
  3. The formations in and along rivers and streams.
    (*a*) The association types of ravines.
    (*b*) The association types of flood plains.
  4. The formations along the sea-coast.
    (*a*) The association types of salt marshes.
    (*b*) The association types of brackish marshes.

D. The secondary formations of hydrarch successional series.

Under subdivisions A B, C, etc. the associations are considered, both specifically and in their successional relations

We see from the above that there is a considerable difference between Tansley's Formations, which include "all the developmental and degenerative stages of an association" and Nichols' Formations which though heterogeneous units developed in a physiographic unit-area, do not include the developmental stages.

Braun's idea of sociological progression although very tempting is not very to easy to apply in practice and hence does not advance much further the problem of a "natural" grouping of plant communities.

Space and time do not allow of my entering into many other interesting developments of our subject. For the same reason I have refrained from entering into details about the quantitative methods of determining the various characteristics of the association. This I could do all the more as in Rübel's "Geobotanische Uutersuchungmethoden" (1922) and Tansley's "Practical Plant Ecology" (1923), we now have treatises for the advanced student and beginner respectively giving in full detail all the information that might be required.

The methods above described can however only be applied with modifications to Indian vegetation. Dudgeon for example finds that the "Succession" point of view is "not entirely satisfactory in the study of the vegetation of India." Messrs. Dudley-Stamp and Lord (1923) have pointed out that the classification of Clements is not suitable for grouping the associations of the riverine tracts of Burma Saxton has recently proposed a new concept of "Mixed Formations in Time" to express the marked periodicity of our climate, etc.

Before closing my address I wish to exhort Indian workers to take up the study of plant-communities which gives an entirely new interest to the study of species and is likely to advance the study of their physiology as well. The very great usefulness of such studies for the management of our forest resources, as well as for the successful growing of agricultural crops demonstrates their economic importance. I hope steps will soon be taken to include the study of plant sociology in the Botany curricula of Indian Universities.

Ladies and gentlemen, I thank you very heartily for the patient hearing you have given me.

Road Slimes of Calcutta.—*By* K. P. Biswas.

An investigation into plant organisms of the slimes that accumulate on the roads and pathways of Calcutta during the rainy season, with an account of the different species of plants which excrete slimes or are present in them.

The plants that are found in the slimes are: *Chroococcus turgidus* (Kuetzing) Naeg., *Chroococcus minutus* (Kuetz) Naeg., *Gloecapsa quaternata* (Breb) kuetz., *Aphanocapsa brunnea* Naeg., *Aphanocapsa grevillei* (Hass) Rab , *Oscillatoria princeps* Vauch., *Oscillatoria tenuis* Ag., *Oscillatoria amphibia* Ag., *Oscillatoria Calcuttensis* Biswas, *Oscillatoria animalis* Ag., *Oscillatoria quadripunctulata* Brühl et Biswas. *Oscillatoria acula* Bruhl et Biswas, *Phormidium tenue* (Meneg) Gom., *Nostoc commune* Vauch., *Nostoc sphaericum* Vauch., *Cylindrospermum bengalense* Biswas, *Scytonema mirabilis* Bornet., *Scenedesmus* sp., *Protococcus* sp., *Cosmarium granatum*, *Closterium* sp., *Eudorina* sp. and *Diatoma* sp. Of these *Oscillatoria Calcuttensis* sp. nova and *Cylindrospermum bengalense* sp. nova are new. The description of these two new species is also included in this paper.

Note on a new branching Botrydium.—*By* M. O. Parthasarathy Iyengar.

A Botrydium which the author collected in January 1922 at Calcutta is described in the paper. This alga differs from the previously described species in having its upper green portion not simple but branched. In its young condition the alga is unbranched but as it grows older, its upper green portion branches. The usual number of its branches is from two to five, but rarely more. One specimen had as many as seven branches. The alga in the opinion of the author is new and has been named by him *Botrydium clavatum sp. nov.*

On a new species of *Oedogonium* from Lahore.—*By* H. P. CHAUDHURI.

A new species of Oedogonium has been studied. It grows well in earth decoction (20% with 1% KNO_3). During a period of three months asexual and the sexual modes of reproduction were studied. The species is a dioecious nanandrous form. The androgonidia in this species are synnonymous with antheridia, which liberate the antherozoid.

An account of the occurence of mutation in Colletotrichum biologicum sp. nov.—*By* H. P. CHAUDHURI.

1. Colletotritum biologicum N. Sp. was collected in Germany in early October 1921, from dying stalks of potatoes.

2. Only innumerable sclerotia with black setae were found in nature.

3. The cultural characteristics of this fungus were studied on different media and under various environmental conditions.

4. On potato-mash agar, Coon's medium and in weak oatmeal agar it produced large sclerotia in concentric rings but scanty mycelia and conidia, but in strong oatmeal agar it produced abundant mycelium with acervuli, as well as sclerotia.

5. Effect of asparagin and maltose on the growth was studied. Asparagin increased mycelial growth whereas maltose increased production of sclerotia.

6. After four months in culture in the Laboratory (16 generations) mutation apparently occurred for it suddenly produced a new strain with a coloured mycelium bearing not only the large sclerotia in concentric rings of the parent form, but also small sclerotia in radiating lines.

7. Though the original strain has been continuously grown in oatmeal agar where it mutated and also in various other media for nearly two years no second mutation occurred.

8. The mutation is permanent and keeps its characteristics in Coons medium and oatmeal agar and no reversion takes place in these but when grown in potato-mash agar, soon loses its distinctive characteristics for good and becomes same as the original when put back to oatmeal or Coon, it could not show the mutant form.

9. No difference in the amount of growth due to the effect of different temperatures has been found. The optimum for both strains has been found to be 27·6.

Observations on the spore characters and histology of some physiological species of Puccinia graminis.—*By* K. C. MEHTA.

1. Discussion of previous work on the morphology of physiological species in general.

2. Discussion of Pole Evan's work on "cereal rusts."

3. Infection histology of Puccinia graminis tritica and P. graminis secalis as cultivated on wheat, barley and rye.

4. Summary and conclusions.

On a Lahore Moss.—*By* L. N. MATHUR.

1. A moss was found at Lahore growing on the bank of the Ravi. Because of its apophysis, which is longer than the capsule, its systematic position among the Splachnacesae was certain, but it was not identified, nor was its life-history worked out.

2. At the suggestion of Rai Sahab Prof. Shiv Ram Kashyap, the writer took the work in hand. As a result of his efforts the following facts may be noted.

3. The plants grow on the banks of the Ravi, though also found in other situations at Lahore.

4. They appear early in December and live till April.

5. In March-April bulbils appear on the rhizoids.

6. The spores of the plant require a period of rest before they can germinate.

7. The gametophyte is small, branched only from the base, autœcious, and without any innovation in the male branches.

8. The sporophyte consists of a foot embedded in the apex of the gametophyte, a slender pale green seta, an enlarged, tapering pale brown apophysis, and a capsule, about half as long and twice as broad as the apophysis.

9. The mature sporogonium is bent, first in the region of the apophysis, becoming greatly convex on one side, and, secondly in the capsule, where the convexity is not so prominent.

10. In the development of its organs the plant resembles Bryales in general.

11. The peristome develops from the third layer of cells from the outside of the lid and not the fifth as described for *Funaria* (Campbell).

12. In the central strand of the foot, unlike that of *Splachnum-luteum*, there is no lepto-phloem (Vaizey).

13 The central strand of the stele does not at a later stage dissolve to form a lysigenous air space.

14. The plant belongs to the genus *Trematodon*, and offers some characters definitely specific, which necessitate the creation of a new species.

15. Some plants were sent to Mr. H. N. Dixon for comparison, who has named them *Trematodon brevicalyx*, sp. nov.

A comparative study of three species of Aneura.—*By* M. A. SAMPATHKUMARAN *and* L. NARAYAN RAO.

1. Three Aneuras A, B, and C, from Mysore, have been studied.

2. The gametophytes of these three Aneuras vary much in shape, thickness, colour, in branching and in habitat.

3. All are dioecious. The archegonia are borne on female plants which are generally bigger than the male plants, in special cups, along the margin in A and B, and at the angle of the branches in C.

4. The Antheridia are borne on the male plants which are smaller and freely branching in B, but have the character of a simple thallus in A. They are found on the dorsal side of the thallus buried in small pits. The development of archegonia and antheridia thus far observed corresponds to the jungermannia type and tallies with that described by Clapp.

5 Chromosomes are six in the gametophyte and twelve in sporophyte of A, but no mitosis was seen in the other two species.

6. The Sporophyte is highly differentiated and very much adapted for the protection and dissemination of spores. Only one-fourth of the potential sporagenous tissue develops into spores, the other three fourths are differentiated into the seta, foot, capsule, elaterophore and elators.

7. The foot is quite characteristic in A and B being a curved structure retaining its apical cell. This fact has not been mentioned in any of the papers consulted.

8. The cells of the gametophytic tissue surrounding the twisted foot, are very rich in cytoplasm with large nucleii. They also abound in starch grains, thus forming the nutritive tissue.

9. The Capsule splits into four valves and this division is seen even at an early stage of development and extends to the contents of the capsule, viz., the elaterophore, elators and spores.

10. The elaterophores project half-way down into the capsule in A and B whereas in C it is not so massive and forms only an apical tuft.

11. Gemmae are found in B. These are borne on long filamentous

stalks and are intermixed with archegonia. Various stages of development of these gemmae could be seen.

12. In some of the mature thallus, a septate fungus has been noticed in the cells of the ventral side. It is similar to the mycorhiza in the gametophyte of Lycopodium.

The genus Notothylas in India.—*By* S. R. KASHYAP *and* N. L. DUTT.

Only one species has been described so far from India and it occurs in the Himalayas. A second species, *Notothylas indica* Kashyap, is described in the paper, occurring at lower levels, at the foot of the Himalayas and the plains of the Northern India. It differs from the already known Indian species, *N. Levieri* Schffn. ms. in having a well-developed columella, a much narrower suture, and wider lumen of the epidermal cells of the capsule. In the form of the thallus, the colour and size of the spores, and the size of the capsule, the two species are very much alike.

Notes on the Morphology and Biology of *Riccia sanguinea* Kash.—*By* S. K. PANDÉ.

1. *Riccia sanguinea* is a very variable species, as regards the size of the plant, the form of the rosette and the colour. The plant is dioecious and the male thalli are usually smaller than the female and of a red colour.

2. No distinctive effects were observed in plants grown under glass plates of different colours; but in all cases there was a feebler development of the assimilatory tissue and the newly formed parts were thinner more pellucid and in all cases green (even in the case of red thalli).

3. In case of plants given an excessive supply of moisture from above the newly formed lobes were narrower and thinner than in the normal plant.

4. The germination of the spore is similar to that described for other species of *Riccia* but the germ-pore is formed in the wall opposite to the triradiate mark.

5. Cases of abnormal development of the young thalli probably due to etiolation have been described.

6. As regards the actual mode of formation of the air chambers, no definite conclusions have been arrived at.

7. The sexual organs are produced in acropetal succession as long as the plant lives, and there is no definite grouping of these organs.

8. The development of the sex organs so far as worked out agrees with the account given for other species of *Riccia*, but in the later stages of the antheridial development certain deeply staining spherical bodies were observed, the significance of which is not clear.

9. In the last division in the cells of the antheridium the spindle is placed diagonally.

10. At no stage in the dividing cells of the sporogonium could a centrosphere or centrosome be demonstrated.

11. The ripe spore is tetrahedral in form and has two protective coats; the outer has a sculpturing of irregular wavy ridges.

"The anatomy of the sporophyte and the development of the sporangium in *Lygodium japonicum* Sw."—*By* H. R. SAINI.

The material used in the investigation was partly collected in Kumaon and partly obtained from plants cultivated in the Government College Botanic Garden, Lahore. The main facts obtained as results of the investigation are given below :—

1. The plants climb by means of the leaf rachises. The leaves are mostly in a single row and the roots also, but at places both approach distichous arrangement The primary root in the hill specimen bore tuberous secondary roots.

2. The stem stele is solid and the leaf trace leaves it with only a superficial disturbance. The protoxylem consists of finely scalariform elements. The cortex of the stem shows three regions.

3. The leaf trace is circular in the cortex of the stem and in the base of the petiole it attains the peculiar outline. There is only one median protoxylem group on the abaxial side. Sometimes there is a small amount of centrifugal metaxylem also. Both these are later on crushed.

4. The root is diarch with two specially large tracheids in the metaxylem.

5. Inside the cortex was found a fungus with broad septate hyphae forming bud-like bodies. Another fungus with extremely narrow hyphae was seen inside the lumina of the tracheids in the stem and the root.

6. The initial cell of the sporangium is marginal and dolabrate. It cuts three segments before cutting off the cap cell.

7. The wall of the sporangium is chiefly formed from the cap cell, the first division of which is perpendicular to the leaf surface.

8. The tapetum is three layered just before the mother cell stage, and breaks down just as the mother cells are formed, the protoplasm and nuclei lying free.

9. There is a quadripolar division in the spore-mother-cells in the formation of tetrads. Tetrads occupy a small portion of the sporangial cavity. From this stage onward the spores develop enormously and fill the whole lumen of the sporangium.

Meiosis in *Equisetum debile.*—*By* M. L. Sethi.

Meiotic nuclear divisions in Equisetum debile have been followed.

The resting nucleus of the spore-mother-cell shows a very complete reticulum with chromatin granules evenly distributed upon it. There are about six nucleoli in the nucleus.

Certain anastomoses of this reticulum are withdrawn during early prophase. The reticulum contracts into a tight knot. This knot loosens into a continuous spireme which shows chromomeres and no longitudinal split. The spireme segments into a number of threads. Second contraction then takes place. From the second contraction emerge young bivalents. During anaphase bivalents separate into their component univalents which move to the spindle poles. Congugation takes place telosynaptically. The number of chromosomes is between 90 and 100.

During interkinesis daughter nuclei show a state of complete rest. Homotypic division then takes place simultaneously in the two daughter cells. Chromosomes divide longitudinally during metaphase and split halves move to the spindle poles. The spore-mother-cell is thus divided into four spores.

The work of the present writer confirms the work of Beer in general outline. The chief difference to be noted is that the open reticulum of E. debile during prophase shows chromomeres and no longitudinal split.

Notes on the Anatomy of a Species of *Niphobolus* from Malay.—*By* B. Sahni *and* S. K. Pande.

The authors describe the physiological anatomy of an epiphytic fern showing a remarkable combination of xerophytic adaptations. Apart from the usual xerophytic characters, such as thick cuticle, sunken stomata, etc., this fern presents the following features:—

1. The root-hairs are persistent, so that even the oldest roots are still covered with them. The copiously branched root-system which spreads out on the substratum is thus loosely bound together into a felt-like pad capable of retaining considerable quantities of water.

2. The thick fleshy leaves consist mostly of water-storing tissue, the cells composing this tissue being remarkable in the fact that they are collapsible and extensible like the bellows of a camera.

3. In the dry condition the transverse section of the leaf is V-shaped, in the wet condition it is nearly flat (cf the leaves of some grasses).

4. The peltate scales densely covering the rhizome are attached by short stalks in depressions on the surface of the rhizome. In section the appearance is remarkably like that of the absorbing scales of the Bromeliaceae. It is probable that the stalks, perform the same absorptive function as in the Bromeliaceae, the dead and thick-walled cells of the "shield" serving as a protection against loss of water.

On the Anatomy of some Petrified Plants from the Government Museum, Madras.—*By* B SAHNI.

Describes the anatomy of three silicified stems belonging respectively to a conifer, a dicotyledon and a palm.

Some observations on *Ophisglossum Aitchisoni Almeida.*—*By* G. M CHAKRADEV.

The species was first found by the author at Siroor in the Poona district in the year 1920 and subsequently named O. Aitchisoni by Almeida The author has discovered a whole society of it on a hill near Poona in 1923 and its seasonal development has been studied. Photographs of the species are taken from pots and in their natural situation (presented on the lantern-slides). Xerophytic forms of the Genus which is normally mesophytic are recorded.

Contributions to the morphology of *Agathis ovata* (Moore) Warburg.—*By* S L. GHOSE.

The material was collected by Professor R. H. Compton in New Caledonia in 1914 and placed by him at the disposal of Professor Seward of Cambridge. The species has not been worked out before. The following points of some phylogenetic importance are recorded for the first time:—

1. In the wood of the stem, root and reproductive axes, no real parenchyma is found, but some vertically-elongated and nucleated cells are given off from the medullary-ray system, which resemble wood-parenchyma.

2. Opposite arrangement of pits on the tracheids is sometimes found in the wood of the stem, root and reproductive axes, but is confined to the region near the transitional zone, where the pitting is irregular, and may be mixed up with spiral thickening. Sometimes the remains of the spirals are found between the pits as short bars and may resemble the 'rims of Sanio.'

3. In the female gametophyte, sometimes a meristematic zone of flattened cells is observed, which divides it into an upper fertile and a lower vegetative region. In one case at the base of the gameto phyte a feeding tissue resembling the 'pavement tissue' of *Gnetum Gnemon* was seen.

4. In the microsporangium well-developed resin-canals are seen in the tissue between the epidermis and the tapetum.

5. The body-cell seems to produce a large number of nuclei two of which are much larger and form the 'male nuclei,' while others seem

to perform some vegetative function. No body-cell with only two nuclei surrounded by a complete wall was observed.

6. After fertilisation the fusion-nucleus is seen to be situated at the bottom of the archegonium. In *A. australis* it has been reported to be near the centre.

On the Origin and Relationships of the Araucarineae.—*By* S. L. Ghose.

1. The Araucarineae are older than the Abietineae.
2. Objections to direct Cordaitalean origin of the Araucarineae, the two main ones being the difference in the plan of the female flower and in the method of fertilisation.
3. A newly-suggested classification of Vascular Plants in the light of the discovery of the Rhynie fossils.
4. The origin of the Araucarineae is traced to some ancient *Lycopodium*-like plants, from which the Cordaitales are also believed to have sprung.
5. The Araucarineae are shown to be related to the Podocarpineae through *Saxogothea*. Their relation to the Abietineae is also indicated.

A Further Note on Two Types in *Andropogon Contortus* (L).—*By* G. M. Chakradeo.

1. In continuation of the previous work on this subject seed of the two newly discovered types of andropogon contortus reported last year was sown separately on the same plot of soil.
2. The two types showed a different course of life history during the season, and thus corroborated the results of the previous paper.
3. Some additional points of difference in the two types such as in colour and leaf-tips have also been discovered.

A note on the sterilization of rice-grains.—*By* S. R. Bose.

Sporing forms of *Bacillus subtilis* are very common on the outer surfaces of rice-grains as well as of other fruits and seeds. They are very resistant and can hardly be removed by treatment with alcohol, carbolic acid, etc. They can be effectively removed by dipping rice-grains in $\frac{1}{1000}$% corrosive sublimate, watery or alcoholic, for 4 to 6 minutes; cultures of such grains after being thoroughly washed in sterile distilled water for about two hours in closed tubes remained perfectly sterile in agar as well as broth media for a number of weeks.

This spore forming bacterium cannot be killed by boiling rice-grains for an hour and half.

To show that corrosive sublimate has no penetrating power and that it cannot enter into the rice-grains in any way, rice-grains were dipped in $\frac{1}{1000}$ corrosive sublimate, watery as well as alcoholic, for ten minutes and longer, sections were made of such grains, and these sections were floated in test-tubes containing super-saturated solution of H_2S for more than half an hour, in each case a yellowish black zone was distinctly found on the extreme outer surface only, which, when chemically tested, was found to be deposit of mercuric sulphide confined to the outer surface.

Gram seeds dipped in $\frac{1}{1000}$ corrosive sublimate for four minutes germinated soon into normal and vigorous seedlings, thus showing that dipping gram seeds in $\frac{1}{1000}$ corrosive sublimate has no deleterious effect on the living cells of the embryo within. The length of time required for killing the spores of this spore-forming bacterium with watery $\frac{1}{1000}$ corrosive sublimate was found to be six minutes.

Some abnormalities in the flower of *Cannabis sativa.*—*By* S. R. KASHYAP.

Occurrence of bisexual flowers, normal or more or less modified, and several intermediate forms between stamens and pistil are described.

Effect of temperature on the ratio of the rates of anaerobic and aerobic respiration in the leaves of *Artocarpus Integrifolia.*—*By* R. S. INAMDAR *and* BHOLANATH SINGH.

Respiration was measured with the aid of a commutator devised by Dr. F. F. Blackman of Cambridge. The amount of CO_2 produced during respiration was drawn by an aspirator through pettenkoffer tubes containing known quantity of $Ba(OH)_2$ and the excess of $Ba(OH)_2$ was titrated against standard HCl. With the aid of the commutator the experiment can be kept running continuously day and night and titrations done at any convenient hour. The hourly rates of respiration can thus be easily estimated from the beginning of the experiment till the end. Separate lots of leaves were used for each experiment conducted at a definite temperature. The temperature was regulated by keeping the experimental leaves in a water bath heated by a thermo-regulator. For temperatures lower than the atmospheric temperature, the leaves were kept in a cool Biological Incubator manufactured by Messrs. Chas. Hearson & Co., London. For aerobic respiration, leaves were supplied with atmospheric air freed from CO_2 by passing it through a tower in which there was a continuous current of potash solution dropping. For anaerobic respiration, the atmospheric air deprived of CO_2 was freed from oxygen by passing the current through Wolf-bottles containing alkaline solution of Potassium Pyrogallate and subsequently in a combustion-tubing containing red-hot copper foil heated in a gas furnace, which removed any remaining traces of oxygen. The air thus freed from oxygen was tested by passing it through cuprammonia decolourised by phenylhydrazine. The experimental leaves were kept in suitable glass chambers fitted with inlet and exit tubes and a thermometer.

The aerobic and anaerobic respirations for a given temperature were observed simultaneously on two lots of leaves. At any given temperature, observations were made on leaves which were plucked fresh from the tree and kept under laboratory conditions overnight, and also on leaves which were starved in the dark for about a week after plucking. Three hourly observations were taken in the case of each experiment till the leaves turned completely chocolate. The experiments were conducted during the summer months from the middle of May to the end of July 1923. A few experiments were also conducted in January 1923, to observe the seasonal effect on the respiratory activity of the leaves. The results obtained show that the respiratory activity during the summer months is, temperature for temperature, much lower than in winter months.

Observations were made during the summer months at 23°C. 27°C. 30°C. 35°C. 40°C. and 45°C and the ratio of the rates of anaerobic and aerobic respirations compared. The rates of both aerobic and anaerobic respirations remain constant, hour to hour, till a temperature of 30°C is reached, in starved as well as in non-starved leaves. But at higher temperatures the "time factor" sets in and the rates begin to fall in successive periods of observations. The "optimum" temperature for the change appears to be 35°C when sometimes the rates remain constant, while at others they begin to fall in time.

The curious fact comes out, however, that the rate of fall due to "time factor" is not proportional in the leaves respiring aerobically and anaerobically. The fall is greater, hour by hour, in the anaerobic leaves than in the aerobic leaves and this difference becomes greater, the higher the temperature. The ratio of the rates of anaerobic and aerobic respirations remains, therefore, constant from hour to hour only during lower temperatures till 30°C is reached. But at highertemperatures, the ratio begins to fall as the experiment is continued in time. This is true both for the starved as well as for the non-starved leaves. Evidently the "time factor" affects the leaves respiring anaerobically more than those respiring aerobically.

The $\frac{\text{anaerobic}}{\text{aerobic}}$ ratio is also compared against temperature both in the starved and the non-starved leaves. In one series of comparisons, the ratios of only the first values that could be observed after allowing sufficient preliminary time are plotted against temperature. In the non-starved leaves this ratio remains constant till 40°C is reached while in the starved leaves, the ratio begins to fall continuously from 23°C upwards. The results thus show that, whatever the mechanism for producing a difference in the operation of "time factor" in the aerobic and anaerobic respiration, it affects the starved leaves more and earlier in temperature than the non-starved leaves.

In the second series of comparisons, the rates of the hourly averages of first 12 hour results are plotted against temperature separately for starved and non-starved leaves. The $\frac{\text{anaerobic}}{\text{aerobic}}$ ratio begins to fall gradually as the temperature rises from 23°C upwards and this fall is greater in starved than in non-starved leaves. The conclusions that (1) the effect of "time factor" is greater for anaerobic respiration than for aerobic and (2) for starved leaves than for non-starved leaves are thus confirmed.

The experiments are being repeated during the autumn and winter months to observe whether seasonal variations in the leaves introduce any difference in the results obtained and whether the "time factor" here observed is of the same nature as is recorded by Kuijper on wheat seedlings and subsequently by Dr. Blackman and his students at the Cambridge Botany School.

Specific Water conductivity of the wood in trees with reference to leaf fall in India.—*By* R. S. INAMDAR *and* AKSHAIBARLAL.

"Specific conductivity" is expressed in terms of "specific volume" which is defined by Professor Farmer as the volume of water transmitted by a stem 15 cm. in length per 1 sq. cm. of wood (in cross section) under a definite pressure of water-column. Experiments conducted at Benares using a lower pressure of water-column than that used by Professor Farmer confirmed the fact that there is a fundamental difference in the specific conductivities of the wood according to the sympodial or the monopodial growth-habit of the tree. In trees where growth is sympodial, the specific conductivity of the apex of the branch falls off rapidly as compared with that of the lower portion, showing a correlation between the death of the apical shoot and the low capacity of the wood for conducting water. In the case of monopodials no such rapid falling off in the specific conductivity can be noticed.

The difference between deciduous and evergreen trees noted by Professor Farmer does not appear to be connected so much with the deciduous or the evergreen habit of the trees as with the demand on the water-supply made by the leaves for purposes of transpiration. If the leaves are "Xerophytic" in construction, the specific conductivity of the wood of a deciduous tree is much lower than that of an evergreen, contrary to general expectation.

The experiments were also extended to observe if there is any correlation between leaf-fall and specific conductivity. Due to variations in the specific conductivity of the wood taken from branches situated at different levels on the tree and from pieces cut at different places on the branch selected for observation, and the consequent great care required to be exercised in using the data for purposes of comparison, observations were made in several ways as follows:—

1. Observations were made at the same time of the year on different trees of a species and on different branches of a tree, some having leaves still attached, others having no leaves and still others showing newly developing young leaves.

2. Comparisons were also made between the specific conductivity of the wood of the same tree at different seasons of the year, viz., once at the time of the leaf-fall and secondly when new leaves were fully developed.

From all these observations, the conclusion is drawn that the capacity of the wood for conducting water is greatest just before and at the time of leaf-fall and decreases considerably later when the new leaves are fully developed. The wood is thus capable of conducting greater quantity of water at the time of leaf-fall but it is suggested that the demand on the water-supply made by the transpiring leaves at that time might be still greater. Consequently at the time of leaf-fall there might be an unfavourable balance existing between demand and supply of water, in spite of an absolute increase in the supply that may reasonably be postulated by an increase in the specific conductivity of the wood at that time. This point can be fully decided only when the relations existing between transpiration and water-supply are thoroughly investigated in different seasons of the year and work in this direction is in progress.

Conditions of starch formation in leaves of *Abutilon asiaticum* G. Don.—*By* R. H. DASTUR.

The present position of our knowledge regarding the photosynthesis of carbohydrates in leaves is stated and the conclusions arrived at by Usher and Priestly, Ewart, Schryver, Warner, Wagner and Jorgensen and Kidd from their experiments are discussed. It is undertaken by the writer to tackle the problem of starch formation in leaves from all points of view and three definite lines of research have been started : (1) To study the conditions of starch formation in leaves of a plant which would be the most suitable for the investigation, (2) To try to determine, as far as possible, by macro or micro-chemical analysis the intermediary products leading to the formation of starch and (3) To prepare a chlorophyll solution from the leaves of the same plant and to determine the effects of various gases on it. The present account refers only to the first one as the other two are still in the process of investigation and the results obtained so far are incompletely worked out.

On experimenting with various plants it was found that *Abutilon asiaticum G. Don.* was the most suitable plant for the investigation on account of various reasons.

Starch appears in twenty minutes after exposure to light when macroscopically examined but microscopical examination shows that it is formed in a shorter period in the second layer of palisade cells its appearance being masked by the intervening layers of palisade and epidermal cells.

Excellent photographic prints are obtained from negatives and a simple method of making these permanent is devised as the iodine starch compound is unstable in light.

Optimum temperature varies between 27C and 29C.

Diffuse light is better suited for starch formation than direct sunlight.

The functional decay of leaves —*By* R. H. DASTUR.

A theory is advanced that the photosynthetic activity of a leaf does not stop suddenly but diminishes slowly as the cells decay one by one on account of the failure of the water supply. The terminal vascular tracheides gradually cease to be functional and the cells which are placed at the greatest distance from these tracheides and so unfavourably with regard to water-supply are the first to become inactive. This phenomenon is quite noticeable in the leaves of many plants as the light green patches which ultimately turn yellow make their first appearance on the margins and the apex and in the meshes of the vascular network where no starch is formed. The photosynthetic activity continues to decrease as the water conducting elements cease to discharge their function one by one beginning from the smallest ones and proceeding backwards towards the main veins.

Though this phenomenon is of general occurrence the leaves of many plants do not exhibit it in the form of yellow patches in the manner described on account of various causes such as the thick texture of the leaves and the retention of green colour by the epidermal cells and the nature of the vacular network.

Physiological Anatomy of the leaf tips of *Gloriosa superba* Linn.—*By* Miss P. M. KANGA *and* R. H. DASTUR.

While studying the histology of climbing organs of indigenous plants of the Bombay Presidency, the authors happened to study the histology of the leaf tendrils of *Gloriosa superba* Linn.

The leaf-tips of the plant are its climbing organs which are very nearly straight in young leaves but form rigid hooks in fully developed leaves. A zone of meristemetic cells gives rise to the swellen leaf-tips and the hooks are formed on account of the adaxial side growing more rapidly than the abaxial side. The epidermal cells with striations on their outer walls and transversely elongated pits on the inner and radial walls form the sensory epithelium for the perception of the contact stimulus. The tissue of the leaf-tip consists of two types of cells the 'living' cells and the 'normal' cells, the former containing the protoplasts and thin circular areas of transversely elongated pits and the latter without the protoplasts but possessing similar pits. The curvature of the leaf-tip is due to the contraction of the living cells on the abaxial side and the elongation of the normal cells. These two types of cells constitute the motor tissue of the sensitive leaf-tip. The elongation of the normal cells is due to fall of turgor and the extensibility of the thin cell membranes.

Inheritance of certain characters in Gossypium.—*By* K. I. THADANI.

The writer briefly reviews the results of investigations on the mode of inheritance of the following characters of economic importance in cotton:—

(1) Seed Fuzziness:—Naked—' wholly' fuzzy—' Partially' fuzzy.
(2) Percentage of Lint:—High—Low.
(3) Length of Staple:—Long—Short.

Seed Fuzziness:—'Naked' seed is dominant to 'wholly' fuzzy seed in the varietal crosses of American upland cottons and behaves in simple Mendelian manner. Crosses between the three subdivisions of 'wholly' fuzzy seeds show that both the 'felted' and 'scanty' fuzz are dominant to woolly and the F_2 generation was small and complicated by difficulty of classifying the Fuzziness. Interspecific crosses between the Egyptian or the Sea Island (partially fuzzy seeded cotton) as one parent and the American uplands (wholly fuzzy seed) as the other parent show that the 'wholly' fuzzy seed is dominant over partially fuzzy seed with one exception and the F_2 population presented such a mass of heterogeneous material as would permit of no grouping.

Percentage of Lint.—'High' lint percentage is dominant to low in the varietal crosses of American upland cottons and their character appears to behave in simple Mendelian manner.

Length of Staple.—'Long' lint seems to be dominant to 'short' lint and in F_2 no theoretical ratios were suggested in the counts.

Owing to the fact that the results obtained differ from those of other cotton workers, the writer concludes that the mode of inheritance in the case of varietal crosses varies for the same characters in the case of crosses between two species and hence cautions plant breeders to accept the result of a set of crosses as being generally applicable. It is further found that most of the desirable characters show dominance and hence are not so easy of segregation as would be the case with recessive characters. It is also suggested that when naked seeds are found mixed in the American cotton seed reserved for planting they should be removed by any simple mechanical device thus effectively eradicating the undesirable mixture in the very first year of planting since fuzzy seeds are recessive and will breed true to type.

Some Remarks on the Vegetation of Western Tibet.—*By* S. R. Kashyap.

The following are the chief features of the climate of Western Tibet:—

(1) Great altitude. The lowest places being above 12,000 feet.
(2) Intense cold, particularly at night.
(3) Strong cold and dry winds.
(4) Absence of water for long distances.
(5) Strong insolation in the day time.

The following are the chief features of the vegetation:—

(1) Absence of trees. The only exceptions are those rare specimens of willows and poplars which are occasionally cultivated in very low places at sheltered spots near villages.
(2) Grass is abundant near streams or lakes, or wherever water is available.
(3) Vegetation in most places is extremely scanty. Only scattered tufts of grass or a few herbs are seen at most.
(4) The general habit of the plants, both herbs and shrubs is cushion-shaped. This is by far the commonest and most striking feature.
(5) Many plants are spinous. Many others have more or less spinous leaf-tips.
(6) Plants have usually long tap roots.
(7) Leaves are usually small and narrow.
(8) Plants are usually perennial.

Caragana and *Arenaria* are the commonest genera in addition to the grasses. *Caragana pygmaca* is a very characteristic plant of the region.

The paper will be illustrated by original photographs.

On the relationships of Indian Moss Floras to each other and to those of Extra-Indian Regions.—*By* P. Brühl.

The paper gives in outline the results of a census of the species of Mosses hitherto reported from Greater India, including in this term the Himalayas, the Indian Peninsula, Ceylon, Further India exclusive of Tonkin, Assam and Cochin China, and the Indian Archipelago. The census discloses serious gaps in our knowledge of the moss flora of this region, and it is one of the objects of the paper to stimulate research in this direction. We have a fair knowledge of the constituents of the moss flora of the Himalayas from Kashmir to Sikkim, a still more complete knowledge with regard to the Nilgiris and particularly of Ceylon, comparatively little is known regarding Chittagong and the Burmese Hill Ranges, and large portions of the Indian Peninsula north of the Nilgiris are practically a *terra incognita.* And even where our knowledge is more complete, it is far inferior to our knowledge of the Moss Flora of Java owing to the labours especially of DOZY *and* MOLKENBOER, VAN DEN BOSCH *and* VAN DEN SANDE LOCOSTE and last, but not least, of MAX FLEISCHER. With respect to the Himalayan Moss Flora an interesting fact brought out by the census is a marked division line between the Western and the Eastern Himalaya. This division line appears to be situated where the single main chain of mountains in the Eastern and Central parts breaks up into several chains in the West, the moss flora in the latter region being closely related with those of Northern Persia, the Caucasus and the Alps, whilst the Eastern Region shows affinities on the one hand with Southern India and Ceylon, on the other hand with Burma and Malaya. It is quite possible that a further detailed study of the Moss Flora of Greater India, based on a more extensive knowledge of the moss flora of the Indian Empire may yield valuable phytogeographical results.

The Cause of Spike disease in Sandal (*Santalum album L*).—*By* P. S. JIVANNA RAO.

1. Introduction.—The paper is in continuation of the author's studies reported in the Indian Forester for 1920, 1921, 1922, where it was maintained that spike is a physiological phenomenon not caused by parasitic organisms or virus

2. Historical.—The two main theories regarding the true cause of the disease are stated, viz.: (i) that the disease is infectious, and (ii) that it is physiological and not infectious.

3. The parasitic habit of sandal and its bearing on the question of spike.—Evidence is given in support of the view that the sandal is an obligate parasite.

4. Experiment.—A sandal tree about ten years old was trenched in such a way that the roots of itself and its hosts were seriously damaged and this resulted in the shortening of the leaves and the accumulation of starch in them. This is believed to be due to shortage of water-supply to the plant consequent on the harm done to the roots.

5. The virus theory in relation to spike disease of sandal.—This theory based on grafting methods is examined and criticised.

6. Conclusions.—From all the evidence available it is concluded that, as the actual spike condition is attained by a process of starch accumulation in the plant and this has been experimentally produced, it also arises in nature when the hosts being shorter-lived than sandal or being otherwise unsuitable fail to supply nourishment. The author thus holds that want of 'good' hosts really serves as a limiting factor for the best growth of sandal and points out that the remedy for spike lies in tending the hosts which is of "far greater importance than any amount of care that may be bestowed upon the parasite."

Anatomy of the aerial root in *Tinospora cordifolia* Miers.—*By* C. TADULINGAM *and* S. N. CHANDRASEKHARAN.

1. Brief botanical description of the plant.

2. The structure of the aerial root showing Velamen, Chloroplasts, Cork and Air spaces.

3. Continuation of the Velamen in the root underground.

4. Peculiar connection of the aerial root with the bundles in the stem.
5. Vegetative reproduction helped by aerial roots.
6. Sieve tubes crossing medullary rays in the stem joining with those of stem and root.

Two New South Indian Plants.—*By* C. TADULINGAM *and* K. CHERIYAN JACOB.

Detailed description and habitat of the two new species—

1. *Biophytum longibracteatum* Sp. Nov. (Geraniaceae-Oxalideae) from Mundanthorai, Tinnevelly Hills, South India. Allied to *Biophytum sensitivum* and *B. Candolleanum* in the Flora of the Presidency of Madras. It is named *Biophytum longibracteatum* on account of its conspicuous long bracts.
2. *Pavonia Coxii*, Sp. Nov. (Malvaceae-Ureneae) from Coimbatore. Allied to *Pavonia procumbens* in the Flora of the Presidency of Madras. It is named after Col. Cox who collected it as early as 1886, though hitherto it was not recognised as a separate species.

Some examples of Plant Teratology from South India.—*By* C. TADULINGAM *and* K. CHERIYAN JACOB.

1. Bulbil in Chlorophytum which shows that bulbils represent modified flowers and not shoots.
2. Stem Fasciation in a wild Indigofera.
3. Stem Fasciation in a cultivated Cucurbita due to super-abundant nutrition.

Specimens will be exhibited.

Some foreign weeds recently introduced in South India.—*By* C. TADULINGAM.

The five plants recently introduced are--

1. *Acanthospermum hispidum.*
2. *Alternanthera echinata.*
3. *Croton Sp.*
4. *Emex spinosa.*
5. *Pilea muscosa.*

Specimens, illustrations and lantern slides will be shown.

Some points in the Physiological Anatomy of the Stilt-Roots of Sorghum and Maize.—*By* G. P. MAZUMDAR.

1. Secondary growth in thickness takes place in the adventitious Stilt-Roots of Sorghum, and perhaps in those of Maize. New Cortical cells are cut off in regular radial rows by a Cambium layer that originates in the layer of Cortical cells just outside the endodermis. The function of this Cambium layer is not to produce new vascular bundles but to replace a portion of the primary Cortex and epidermis that have been lost owing to their walls becoming mucilaginous and the death of their contents.
2. In the secondary and tertiary stages when the endodermal cells of these roots become greatly thickened certain peculiar slightly stalked spherical bodies are developed on their inner tangential walls. The latter are provided with numerous pits under these structures. They are highly resistant to strong mineral acids. The lateral roots that develop when these roots reach the soil are also surrounded by sheaths with these bodies. In function they may be compared to the Fibrous Bodies of Meinecke developed in the Velamen, and perhaps like them

absorb water from the Cortical cells and transfer it to the vessels and tracheides through the pits in the walls underlying them.

A note on the anthesis of Pennisetum typhoideum.—*By* G. N. RANGASWAMI AYYANGAR.

Preliminary observations on the anthesis of Pennisetum typhoideum were made and the fact that its anthers were exserted throughout the day and night, with a concentration at past midnight and weakening towards evening, are noted. Observations on the flowering of the other local Pennisetums are recorded and the significance of the phenomenon as it affects breeding this crop is discussed.

Section of Geology.

President:—Dr. W. F. Smeeth, M.A., A.R.S.M., F.G.S.

Presidential Address.

SOME VIEWS ABOUT THE ARCHAEANS OF SOUTHERN INDIA.

In taking the chair at this section of the Congress I am acting purely vicariously as an emergency Chairman. Mr. P. Bosworth-Smith had been selected as your President and I am sure you will all join with me in regretting that ill-health has prevented him from fulfilling the engagement and has caused us to lose the pleasure and profit of listening to an address from him based on his exceptionally long and wide experience of the Geology of India—especially on the economic side.

I have to apologise for not having had either the time or the facilities for preparing a worthy substitute and must content myself with offering you a few cursory remarks about some points connected with the Archaean complex of Southern India, a subject which has already received attention in several previous addresses.

Various Views.

In my address to this section at the Madras Congress in 1915, I gave a sketch of the Geology of Southern India based on the work of the Mysore Geological Survey and a condensed map, on a scale of 8 miles to an inch, showing the main outlines of the results of that work was published in the same year. I have hung up a copy of the map for convenience of reference and also a tabular statement[1] showing the various views which have been entertained from time to time regarding the relationships of the various components of the Archaean complex.

Nowbold (1850) regarded the complex as formed of Protogene Schists and Gneisses intruded by various Granites. Bruce-Foote (1880) separated the schists (to which he gave the name " Dharwar System ") from the gneisses and regarded the former as largely of sedimentary origin, with some intercalated traps, and as laid down unconformably upon the gneisses and granites. This great complex of granitic gneisses and granites was regarded by him as the basement rock or " Fundamental Granitoid Gneiss " and continued to be so regarded for many years. In 1893 Oldham gave a classification in which

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[1] *Vide infra.*

Classifications of Pre-Cambrian Rocks of India.

Newbold (1850) (*Mysore*).	Bruce Foote (1880) (*Mysore*).	Oldham (1893) (*India*).	Holland (1906) (*India*).	Holland (1913) (*India*).	Lawson (1913) (*Canada*).	Smeeth (1915) (*Mysore*).
			Pre-Cambrian. Vindhyan	Purana. Vindhyan	Algonkian. Keweenawan	Pre-Cambrian.
		Older Palæozoic. Vindhyan	Kurnool (Upper Cuddapah)	Upper Cuddapah, etc.		
				(Unconformity)	(Unconformity)	
		Cuddapahs.	Lower Cuddapah Gwaliors, etc.	Lower Cuddapah, etc.		
					Animikie.	Basic dykes (chiefly dolerites).
Dykes of basaltic greenstone.	Dykes of dioritic trap	Dykes.	Dykes.	Dykes.		
			Gt. Eparchæan Interval.	Eparchæan Interval.	Eparchæan Interval.	Eparchæan Interval.
Granites				Vedic. Post-Dharwar Eruptives.	Archæan. Algoman (granite-gneiss)	Archæan. (1) Closepet granite complex and other granites.
(Irruptive Contact)				(Irruptive Contact)	(Irruptive Contact)	(2) Charnockites.
Hypogene Schists. Limestone, talcose and argillaceous schists, chloritic actinolitic, hornblende and mica schists.	Dharwars. Limestone, argillite, quartzite, intercalated traps, hornblende schist, chlorite schist, haematite-quartzite, mica schist.	Transition. Dharwars Champanirs, etc.	Archæan. Dharwars Eruptive gneisses, granites, charnockites, anorthosites of Bengal.	Dharwars (Unconformity) Deformed eruptives, "Bundelkhand" gneisses.	Huronian: Upper (Unconformity) Lower. (Unconformity) Laurentian (granite-gneiss)	(3) Peninsular gneiss (granitic). (4) Champion gneiss (granitic). (Irruptive Contact). Dharwars: Upper Division (chloritic). Lower Division (dark hornblende schists, epidiorites, etc.).
Gneiss	Fundamental granitoid gneiss. Chloritic, micaceous, granitoid.	Metamorphic and Crystalline. Gneiss, gneissose-granites, schists, etc.	Schistose gneisses. Oldest gneisses.	(Irruptive Contact) "Bengal" type of schist (gneiss). Oldest gneisses.	(Irruptive Contact) Ontarian: Keewatin Coutchiching.	(Unknown.) Note:—[*(1) (2) (3) (4) in order of intrusion.*]

the Dharwars were regarded as transition rocks between the fundamental gneiss and a group of older palaeozoics represented by the Vindhyans and Cuddapahs.

Holland (1898) differentiated the Charnockites, showing that they formed a distinct petrographical province with intrusive relations to the main members of the gneissic complex, and in 1906 he proposed to regard the Vindhyans and Cuddapahs as Precambrian and separated by a great Eparchaean Interval from the Dharwar System which, together with the Fundamental gneissic complex, he classed as Archaean. In 1913 Holland added a group of Post Dharwar eruptives and produced a classification of the Precambrian rocks of India which exhibits a remarkable parallelism with that given by Lawson (1913) for the Precambrians of Canada.

In 1915 I produced a classification, based on the work of the Mysore Geological Survey, in which the Dharwars were put down as the oldest known rocks of the Archaean complex and the so-called Fundamental gneissic complex was held to consist of several gneissose or granitic formations (with a definite order of succession) all of which appeared to be younger than the Dharwars and showing, where definite evidence was forthcoming, intrusive relations towards the latter.

Comparing this classification with that given by Lawson for Canada it will be seen that the Dharwars correspond in position to the Keewatin Series and this correspondence is emphasised by considerable petrographical similarity. The great succession of gneisses and granites of Peninsular India would seem to correspond with the Laurentian and possible Algonkian formations of North America while representatives of the Huronian formations have not been found.

The contentions which I put forward in 1915 have received a gratifying amount of attention and a good deal of courteous and illuminating criticism and, I may add, a good deal of support.

Mr. Middlemiss dealt with them at some length in his Presidential Address before this Section in 1917 and found them unacceptable. He preferred to adhere to the view that the Dharwars had been laid down unconformably on the gneisses and that where evidence of intrusion was found it might be regarded as due to local refusion or plastic deformation and penetration. Although strongly in favour of the older views he appears to me to keep a perfectly open mind in the matter and very fairly requested that more detailed and specific evidence of the facts upon which the Mysore conclusions are based should be furnished. Again, Dr. Fermor, in his Presidential Address in 1919, devoted considerable attention to the views I expressed in 1915 and accords them a gratifying measure of support. With his experience over a much wider area than has been examined by the Mysore Survey he states that "as regards the relationships of the Dharwars to the 'Fundamental gneisses,' all the evidence I have seen forces me to the same conclusion as Dr. Smeeth, namely that the Dharwars are the oldest rocks wherever they occur and that the associated gneissose and gneissose granites are intrusive in their relationships."

Fundamental Gneiss and Refusion.

This being so, we are faced with the problem of what has become of the old land surface or basement rock on which the great Dharwar series must have been laid down or poured out. Dr. Fermor shares with me an intense repugnance to any suggestion that the Dharwars might once have been suspended in mid air with no visible means of support. Where then is the supporting rock which once existed? I have spent more time in vainly seeking for traces of it than in investigating intrusive contacts or turning igneous bodies into imitation sediments. Dr. Fermor seems to have had no better luck farther north and it is certainly remarkable that over such a large area no clearly recognizable remnants of the base of the Dharwars or of the basement rock on which they originally rested should still remain. A similar state of affairs appears to prevail amongst the Archaeans of North America where the great Laurentian gneisses show intrusive relationships to the older Keewatin series and where neither the basal members of the series nor the basement rock on which they rested has been clearly identified. To meet these difficulties Dr. Fermor adopts the hypothesis that Dharwars together with the original rocks on which they rested were once so deeply submerged that the lower portions suffered refusion which not only destroyed the identity of the basement rocks but provided the material which now forms the great mass of the gneiss and furnishes intrusive contacts with the unfused remnants of the Dharwars.

Very similar suggestions have been made in the case of the Laurentian gneisses of North America upon which Van Hise and Leith make the following comment.[1] "In limited areas evidence of subcrustal fusion seems to be reasonably conclusive, but to the present time the quantity of material which has been proved to be of this origin is insignificant as compared with the masses of igneous rocks in the Archaean. In the nature of things, conclusive evidence could scarcely be expected throughout the masses; that subcrustal fusion has taken place upon such a scale as to account for any large part of the Laurentians is yet unproved."

So far as I am aware the same opinion may be expressed about the Archaean gneisses of India; and in Mysore I have not seen anything which I would regard as representing the base of the Dharwars and their original basement rock refused *in situ.* We claim to have identified several granitic gneisses of successive ages and with intrusive relationships to the Dharwars. The earliest of these, namely the Champion gneiss, has penetrated the Dharwars in sills and bands which have suffered much folding and shearing along with the enclosing schists. If any portion of the gneissic complex is the result of refusion of Dharwars and earlier rocks this earliest Champion gneiss must have been such a portion or must, at any rate, have suffered in the regional refusion. The enclosing schists however exhibit no signs of such refusion and in many cases retain their original igneous texture. Thermal contact effects are of course abundant and tongues of the gneiss have absorbed a certain amount of the enclosing schists with production of fine mica-hornblende gneisses or mica-schists; and in the Sulekere area there are very considerable masses of such mixed contact rocks in close proximity to schists which certainly have not suffered regional refusion. I have seen nothing which cannot reasonably be explained by ordinary plutonic injection of an acid magma. The same may be said of the much larger masses of the later Peninsular gneisses which are composed of gneissose granites of various types injected in successive stages. The contact effects are very variable. In some cases there has been contact absorption forming mixed rocks and there are some large masses of such mixed rocks not in contact with the schists which may represent masses of schist which had foundered and been absorbed or refused. On the other hand, there are patches and even angular blocks of the hornblendic schists included in the gneiss and sharply separated therefrom in such a way as to render it extremely improbable that they have ever been drawn into the zone of regional refusion

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[1] Precambrian Geology of North America. Bull. 360. U. S. Geological Survey.

Still later we have the Charnockite series of gneisses, to say nothing of later granites, and it would be interesting to enquire of those who regard the intrusive gneisses as merely refused portions of the earlier basement rocks whether they would restrict this mode of origin to the earliest formed Champion gneiss which is most intimately associated with the Dharwar schists or whether they would suggest several periods of refusion to account for the very diverse materials which go to form the Peninsular gneiss and the Charnockites and which were successively intruded during a lengthy period of time.

On the whole, the evidence I have seen in Mysore is in consonance with the view that the gneisses are intrusive rocks of plutonic habit. Elsewhere the evidence may be different and I have nothing to say in principle against the possibility of regional refusion and injection of the fused material into unfused portions of the same series of rocks.

The hypothesis of refusion of the base of the Dharwars has been put forward to account for the fact that no remnants of that base nor of the underlying basement rock have, so far, been clearly identified and it may very reasonably be contended that the refusion took place at a much greater depth than was ever reached by existing remnants of the Dharwar schists in which case the injection of the refused material into those remnants would be comparable to the injection of plutonic magmas such as we find to be the case.

It seems to me to be very much a question of more or less. If the basement of the Dharwars got down to the zone of refusion I presume that the other rocks down there must also have been in a molten or potentially molten condition and when the movements resulting in intrusion took place there must have been considerable intermingling of the magmas. Whether the base of the Dharwars was stoped away or foundered in solid blocks into a deep seated magma or whether it was first fused and then commingled with the latter I think, we may take it as quite certain, that the intrusive gneisses contain variable amounts of the Dharwar schists and of the rocks on which they originally rested.

Whatever may have been the exact sequence of the event and whatever the history of the origin of the intrusive gneisses I am still content with the position I adopted in 1915, namely, that the gneisses are essentially intrusive into the Dharwars and that the latter were not laid down unconformably on the upturned edges of the former. On the other hand it is still permissible to hope that somewhere amidst the wide-spread Archaeans of India an undoubted basal section of Dharwars will be found resting unconformably on that older "fundamental" rock the character of which still remains "unknown."

Divisions of the Dharwar Schists.

I now pass on to say a few words about the Dharwar schists themselves.

In 1915 I divided the Dharwar schists into :—

(1) an *Upper* division largely composed of green stones and green-stone schists which are characterised by the presence of chlorite and absence of hornblende and,

(2) a *Lower* division composed almost entirely of hornblendic schists, epidiorites and traps characterised by the presence of dark blue-green hornblende and absence of chlorite.

This distinction is purely stratigraphical—a matter of position—and does not necessarily imply that the lower is older than the upper division.

As a matter of fact we find many instances where the dark hornblendic rocks—especially the coarser varieties—show intrusive relationships to members of the chloritic division :

we also find bands or sills of the former intercalated amongst the latter and we even find that some of the dark hornblendic rocks show intrusive relationships to other bands of the same series in such a way as to suggest that they are sills or later injections.

It seems clear that some of the rocks which, for convenience of mapping, have been included in the *lower* division are intrusive towards other members of the same division and also intrusive towards members of the *upper* or chloritic series; and it is a point for further consideration and study whether the whole of the dark hornblendic rocks may *not* be later than, and intrusive towards many members of the upper division. The direct evidence does not at present permit of a final decision as to whether some of the dark hornblendic schists and epidiorites do or do not represent lava flows underlying or intercalated with members of the chloritic series (which appear to be derived from igneous rocks of not dissimilar compositon); but it is open to suggestion that the whole of the dark hornblendic rocks may be comprised of sills, dykes, stocks, and bosses somewhat later than, and intrusive into an older series now represented by the chloritic and other rocks of the upper division. In cases like the Kolar schist belt, which is composed almost entirely of the dark hornblendic series, we should have to regard these sills and other intrusive masses as so large or so juxtaposed as to exclude any visible remnants of the earlier series which they penetrated.

Speaking generally, I have always had the impression that much of what I have called the *Upper* division presents an older aspect than the members of the dark hornblendic series both in regard to mineral alterations and mechanical deformation. In the latter series it is true that there has been complete alteration of original augite to hornblende—assuming that the original rocks were normal basalts and diabases of varying degress of coarseness—but beyond this change there has been little mineral or textural alteration except along shear zones or near contacts with later acid intrusives In many cases original igneous textures are well preserved.

On the other hand, the greenstones and greenstone schists of the *Upper* division—which probably are derived from basic igneous rocks differing but little in composition from those of the *Lower* division—have lost not only all traces of original augite but practically all traces of hornblende also and are rich in chlorite, or chlorite and talc or mica and frequently exhibit much evidence of silicification and calcification. Mechanically, they show, in my opinion, much more folding, crumpling and shearing than most of the members of the *Lower* division.

Associated with the greenstone and chlorite schists are many acid types such as felsites, porphyries, quartzites and mica gneisses or schists which go to form part of the *Upper* division of the Dharwars. Many of them are regarded as igneous intrusives and as having a genetic relationship with the Champion gneiss In that case they would also be intrusive towards the dark hornblendic rocks of the *Lower* division since the Champion gneiss is typically intrusive towards the latter.

Possible Pre-Champion Gneiss.

These relationships appear to be a bit involved and the abundance of some of the acid types referred to in the *Upper* division contrasted with their relative scarcity or absence amongst the rocks of the *Lower* division is difficult to explain if they are all derivatives of the Champion gneiss and hence later than both divisions of the Dharwars. The character and distribution of these acid types require much further study and it may be suggested that some of them should be associated with a period of granitic intrusion still earlier than the Champion gneiss but of which period the primary granite or gneiss has not been identified and separated. Remnants of this earlier gneiss might easily remain amongst the very varied types which at present are included under the designation "Champion gneiss."

The assumption of a Pre-champion gneiss would not help any more that the Champion gneiss itself—to explain the relative abundance of acid types (sills etc.) in the *Upper* division of the Dharwars if the dark hornblendic schists of the *Lower* division were already in existence prior to the intrusion of such a gneiss and its subsequent associates. On the other hand it would afford such an explanation if we assume, at the same time, that the dark hornblendic rocks are later than and intrusive towards the chloritic members of the *Upper* division and that the acid intrusion took place prior to the intrusion of the dark hornblendic rocks. These two assumptions would serve also to explain the relatively greater metamorphism of the rocks of the *Upper* division.

Evidence of the banded Quartz-Iron Ore series.

Leaving these suggestions for what they are worth I turn for a moment to the evidence afforded by the great series of the banded quartz-iron ore rocks.

These strongly marked and highly resistant types—whether they are regarded as originally derived from sediments, subaqueous lava flows, or widely extended intrusive sills—afford in many cases valuable tectonic indications. The structural features of the bands and their relationships to the adjacent schists, however, are often obscured by the fact that the adjacent schists, which have been protected from denudation, are highly weathered and their original characters unrecognisable and also by the fact that a heavy talus of blocks and fragments of the banded iron stones usually conceals the contacts.

In spite of this we can, I think, draw certain inferences from the occurrence and disposition of these banded iron stones as revealed by the mapping so far accomplished.

In the first place it will be obvious from inspection of the small scale map which has been published that these banded iron stones are most extensively developed in the schists of the *Upper* or chloritic division. Further it may be noted that the outcrops of the banded iron stones are more continuous—in spite of dislocations due to faulting and shearing—in the chloritic than in the hornblendic schists and more comparable to beds or intercalated bands in the former than in the latter; and the suggestion I wish to offer for further consideration and study is that the banded iron stones are mainly or wholly members or intrinsic associates of the chloritic series and that they occur in the hornblendic series merely as inclusions or caught-up patches of the chloritic series due to the intrusive relationship of the former towards the latter.

Before referring to the evidence afforded by the mapping already accomplished I may guard myself by stating that these banded iron stones present considerable diversity of character representing, doubtless, diversity of origin or development and it is quite possible that some of them may be true associates or members of the hornblendic series, just as at a later date we have quartz-magnetite bands which are genetic associates of the Charnockite series. Such instances, if found and proved, will not, however, affect the main argument which I will now illustrate with the aid of the map before you. Where the banded iron stones lie wholly in the chloritic schists—as in the big fold between Harihar and Sulekere—in the much folded region North and South of Shikarpur—around the northern end of the base of Champion gneiss running N.N.W. from Choradi, and around the periphery of the granite intrusion north and south of the Marikanave Lake—they appear to follow the outcrops and foldings of the enclosing chloritic and micaceous rocks and behave as intercalated beds flows or sills.

Again in the long strips of the chloritic series which terminate to the north-east and south-west of Kalasa on the Western Ghats, we find numerous bands of the iron stones which curve round at their southern ends in such a way as to suggest that both the iron stones and the enclosing chloritic rocks are synclinally folded cappings resting on the underlying dark hornblendic schists and this formation could be explained either on the assumption that the chloritic schists and iron stones were resting conformably on an older series of the dark hornblendic rocks or that the latter were intrusive sills and masses which had caught-up the former without materially disturbing the continuity of their outcrops. In the case of

Baba Budan Hills to the north-west of Chikmagalur we have a horse shoe like chain of hills surrounding the Jagai valley. The crest of the chain is formed of banded iron stones dipping inwards towards the central valley. At the western end of the horse shoe, near Hebbe, the banded iron stones cross the valley of the Somavahini dipping to the east and the dark hornblendic schists are both underlying and overlying the iron stones.

On the other hand at the eastern and north-eastern sides of the horse shoe (round about Kalhattigiri) we find the iron stones resting on or intercalated with members of chloritic series which rest on the dark hornblendic rocks and this difference between the eastern and western ends of the chain may, I think, be most easily explained on the assumption that the dark hornblendic bands and masses are intrusive towards the chloritic rocks and iron stones. It may be noted that some of the more massive members are clearly intrusive into the chloritic bands and iron stones in several places (for instance near Hoskan and Kemmangundi) and it is not clear whether more massive intrusions should properly be regarded as members of the *Lower* hornblendic division or as subsequent to both divisions. In other words, while they do not afford direct proof of the intrusive character of the dark hornblendic rocks as a whole they are at any rate not inconsistent with such a view.

There are some other localities in which the chloritic schists and their included banded iron stones appear to be abruptly cut off by the dark hornblendic series. A case in point is the Karakurchi hill four miles west of Dodguni in the Tumkur district. The map shows a tongue of the chloritic schists with several steeply inclined beds of banded iron stones all abruptly terminated to the south by dark hornblendic rocks. There is no discernible tendency for the iron stones to join together at the tip of the tongue such as would be the case if they represented a synclinal fold resting on the underlying rocks and, if we exclude faulting of which there is no evidence, the most reasonable explanation would be obliquity of contact due to the hornblendic rocks being intrusive towards the chloritic schists and iron stones.

In several places bands of the banded iron stones are shown lying in the dark hornblendic schists without any recognisable layers of the chloritic in juxtaposition and it is necessary to consider how such cases would fit in with the suggestion that the iron stones are essential components of the chloritic series and that the dark hornblendic rocks are intrusive towards them.

In the first place, owing to excessive decomposition of the rocks immediately adjoining the ironstone bands it is extremely difficult to recognize the original characters of the contact rocks and therefore difficult to say whether shreds of the chloritic series may have been present or not.

It has already been pointed out that many members of the chloritic series are more highly altered than the hornblendic rocks and amongst the former, the banded ironstones have undoubtedly suffered great mineral and structural changes. Whatever may have been the original material from which these finely banded, and often highly crumpled quartz-iron-ore rocks have been derived there can be little doubt that the minerals and structures are mainly secondary. These secondary changes took place in very early times and the iron stones assumed their present banded character before the intrusion of the Champion gneiss. This is shown by the strips and fragments of the banded ironstones which are included in the gneiss and in the autoclastic conglomerates associated with it. The Champion gneiss is intrusive into the hornblendic schists but it is quite possible—I may say probable—that the banded ironstones took on their present characters before the intrusion of the dark hornblendic rocks. This appears to me to be in accordance with the highly metamorphosed character of the banded ironstones and the comparatively slight changes which hornblendic rocks have suffered at comparatively close quarters.

One of the best known occurrences of banded ironstones lying apparently in the hornblendic schists is the western ridge of the Kolar Schist Belt. This ridge extends for several miles and is composed of vertical or steeply inclined bands of the banded iron stones with fresh and but slightly altered hornblendic rocks within a short distance on either flank. It is difficult to explain the distribution and occurrence of the ironstone bands on the assumption that they were once beds, flows or sills intercalated with the members of the hornblendic series. The number of the bands varies abruptly from two upto half a dozen at different points and although a certain amount of this variation may have been due to faulting or longitudinal slides I do not think such an explanation adequate to account for the greater part of it.

Again at Woolamakonda hill, at the extreme south end of the schist belt in the Mysore State, several strongly marked and nearly vertical bands terminate very rapidly and are succeeded to the south by hornblendic schists The contacts are obscured by talus but no tendency for the bands to coalesce has been detected, as would be the case if they were folded layers of the hornblendic series. A similar state of affairs exists at Yerrakonda hill towards the eastern side of the schist belt. The hill being formed of strongly marked bands of ironstone in decomposed schists which are cut off to the north by the Champion gneiss and succeeded to the south by a solid area of hornblendic schists.

Another point which renders it difficult to explain the mode of occurrence of these ironstones is the fact that strongly marked vertical bands which occur on ridges often fail to pass across the low saddles between the ridges or to coalesce at the ends of the ridges. This is found to occur not only in the Kolar schist belt but also in the Chitaldroog schist belt where the ironstones are enclosed in the chloritic schists; and in the latter case the explanation is to be sought in the intrusive masses and bands of the *grey trap* of the Chitaldroog district which are intrusive into both the chloritic and hornblendic series.

I have said enough to show that there is considerable amount of evidence which is not inconsistent with the view that the dark hornblendic series is intrusive towards the main mass of the Dharwar Schists as represented by the chloritic schists etc. of the *Upper* division, in spite of the fact that in Mysore the former are mostly found underlying the latter, and I trust that the suggestions I have put forward will stimulate closer and more critical study.

Inclusion of the Champion Gneiss in the Dharwar System.

In his Presidential Address to the Geological Section of this Congress at Nagpur in 1920, Prof. Sampat Iyengar draws attention to the very intimate association of the Champion gneiss and its allies with the Dharwar schists in the following words:

"From the foregoing brief account it should be evident that a considerable portion of the Dharwar schists in Mysore is composed of schistose rocks which are the derivatives of the Champion gneiss and the nomenclature Dharwar System should, therefore, include the latter. As it is erroneous to separate the schistose representatives from their progenitors by any long time interval and as the Champion gneiss has been shown to be older than the Peninsular gneiss I am of opinion that the expression "Eruptive unconformity" appearing in the tabular statement on page 20 of the "Outline of the Geological History of Mysore" between the rocks of the Dharwar System and the Champion gneiss should be between the latter and the next succeeding formation, the Peninsular gneiss, and that the Dharwar System should be made to include the Champion gneiss as well."

I am entirely in favour of including the Champion gneiss with the various offshoots, contact alterations etc., in the Dharwar System. Apart from the fact that many acid members of the Dharwars are held to be related to the gneiss the occurrence and distribution of the larger masses are intimately connected with the schists, have suffered much of the same folding and are practically always found in the residual patches of schist embedded in the great Peninsular gneiss. In 1915 my main object was to show that the Dharwar schists were not laid down on the great mass of the Peninsular gneiss and the best proof of this was the recognition of an earlier gneiss which was intrusive towards the schists but intruded by the Peninsular gneiss; and to emphasise this I inserted the word "Eruptive unconformity" between the Dharwar schists and the earliest or Champion gneiss. If we now embrace the latter in the Dharwar System the eruptive unconformity will still remain but the scheme given in 1915 can be suitably revised to include this change and to include, tentatively, the suggestions made in this address as to the relationships of the main divisions of the schists themselves.

A Palæolithic Settlement and Factory in the Mysore State.—*By* P. SAMPAT IYENGAR.

At the eastern foot of the Banasandra hill range one mile south of Biligere, Tiptur taluk, palæolithic implements were found by me in large numbers over an area of nearly half a square mile. Some of them were picked up from the gravelly layer below a thick accumulation of rain wash or brick earth. This discovery is of great significance since no palæolithic settlement or factory in Southern India is known to exist.

The locality is an ideal one for the habitation of palæolithic men and reasons are given in the paper why it has been considered their settlement and factory.

The large number of implements collected from here are classified under Eoliths and Palæoliths. Many types of domestic implements such as hammer-stones, combination scraper and borers, scraper and swords, curved saws, guillotine chisels, skin curers, etc., and those intended for warfare such as arrow-heads, javelin axe points and circular sling stones are described. From the size, shape and finish of the several implements it has been inferred that the palæolithic men in Southern India were clever and intelligent.

Description of the mineral Monazite occurring near Bangalore.—*By* P. SAMPAT IYENGAR *and* K. SRINIVASAN.

The crystals of Monazite which were found so far back as the year 1912 in the pegmatite veins at Yadur close to Bangalore were studied carefully and the results obtained are now given. Descriptions of the associated minerals are included. The crystallographic descriptions and drawings of the monazite including the twins and parallel growths noticed, and the interfacial angular measurements form the special feature of the paper. Finally the optical properties observed in thin sections of the mineral are mentioned.

Notes on the Geology of Kohat, with reference to the homotaxial position of the Salt Marl at Bahadur Khel.—*By* L. M. DAVIES.

The author, a Military Officer stationed at Kohat, with detachments to visit in the Bunnu area, has availed himself of his opportunities to compare the Nummulitic series at Kohat with that overlying the well known Salt deposits at Bahadur Khel. He finds that a very reasonably close correspondence can be made out; the series at Bahadur Khel (between the Miocene sandstones and the Gypsum) corresponding to beds 5 to 8 of his series at Kohat. A particular examination is made of bed No. 5 in each series; and this is found to correspond not only (1) in position, but also (2) in internal structure, and (3) in possessing a very similar fauna (identified by Dr. Coggin Brown) which is especially characterised by the presence of *Nummulites laevigatus* var *scabra*, and a well-marked

Lepidorbitoidal form. Other foraminifera from this bed are *N. perforatus* (*crassus* type), *Assilina spira*, and *Alveolina oblonga* and *javana*.

The fauna of this bed is discussed, and regarded as representing a lower middle Lutetian, or basal Khirthar horizon; while the fauna of the next fossiliferous beds below (Nos. 9 and 10 of the author's Kohat series) is regarded as representing a lower Lutetian, or Laki horizon.

The author then describes the recent discovery, by Mr. D. N. Wadia, of the fact that the gypsum at Bahadur Khel has been produced by the alteration of a series of limestones and marly strata underlying the red sandstones and clays which have hitherto been generally regarded as the lowest members of the Nummulitic series at Bahadur Khel. The author regards these gypsified beds as probably corresponding to beds 9 to 11 of his Kohat series, since (1) their position, and (2) their general character, seem to indicate this. He also records (3) the finding of what seem to be traces of small Nummulites in them, resembling those of bed 9 at Kohat. He concludes:—

1. That the gypseous series at Bahadur Khel consists chiefly, if not entirely, of altered sedimentary deposits whose original character was that of interstratified limestones and clays; and
2. That these, the lowest beds above the Salt, are probably of "Laki," or Lower Lutetian character.

On the mining, dressing and valuation of Patharachata china clay.—*By* K. K. SEN GUPTA.

In this paper the author gives a general description of the deposit, proper mining methods to be followed, the quantity of cornish stone available, the quantity of finished product after levigation, the market price and the basis of calculation and valuation of the property.

On a pre-sacral vertebra of *Titanosaurus Blanfordi*, Lyd. from the Lameta beds of Pisdura, Chanda (C.P.).—*By* H. C. DAS GUPTA.

From a study of some of the pre-sacral vertebrae of *Titanosaurus australis*, Lyd. found in Patagonia, Lydekker came to the conclusion provisionally that the pre-sacrals of *Titanosauridae* were opisthocoelous. The writer of this note has described a vertebra of *T. Blanfordi*, Lyd. This vertebra is supposed to belong to the lumbar series. It is procoelous and not opisthocoelous.

On the occurrence of *Scylla serrata*, Förskal in the Upper Tertiary beds of Hathab, Bhavanagar (Kathiawar).—*By* H. C. DAS GUPTA.

Fossilised specimens of the common edible crab of India (*Scylla serrata*, Förskal) have been known for a very long time, i.e., since 1767, but precise data ragarding locality and the age of the beds have been wanting. The sternal portion of a fossil crab from Hathab, Bhavanagar State, has been identified as *Scylla serrata*, Förskal. The age of the beds is Miocene.

Notes on the Geological section at Shahabad, Hyderabad State, Deccan.—*By* P. SAMPAT IYENGAR.

The Geological section represents a traverse across the Bhima series for a distance of four miles. The famous limestone beds of Shahabad together with the underlying shale and conglomerate, constituting the Bhima series, lie unconformably over the granite complex and are folded up into a gentle anticline. At Bankura village this anticline is denuded exposing the basement granite complex.

The paper gives also a brief description of the rocks met with in the area.

On the Phosphatic nodules from Utatur.—*By* L. RAMA RAO.

The paper describes the Phosphatic nodules found in the Cretaceous beds at Utatur, Trichinopoly District, and gives the result of the examination of sections of these nodules under the microscope with special reference to the fossil Foraminifera found in them. The question of the probable mode of origin of these nodules is also considered, and a manner in which the direct concentration of the phosphate may have been brought about in these nodules is suggested.

Considerations regarding the origin of some of the Asbestos veins of Hole Narsipur area (Hassan District).—*By* B. RAMA RAO.

In a brief note touching upon the classification, chemical composition, mineral habits and physical properties of asbestiform minerals in general, the terms cross-fiber, slip-fiber and mass-fiber as applied to veins of such minerals are explained. Three types of asbestos are recognised in the Hole Narsipur area, viz., anthophyllite, tremolite and chrysotile. Of these, the first two show both cross-fiber and slip-fiber structures while the chrysotile veins of the area appear to be only of the cross fiber type. Regarding cross-fiber veins of anthophyllite, after pointing out the difficulties for accepting their origin as due to deposition of material from solution in pre-existing fissures by any one of the methods noted in the paper, on the strength of certain observed facts, an original magmatic origin is claimed. They are regarded as contemporaneous veins, with the development of an incipient asbestiform structure which is shown to have been subsequently accentuated by the action of meteoric waters.

The asbestos veins in serpentine rocks, have been ascribed to the following three different modes of origin :—

(1) Due to crystallisation *in situ*, of serpentine.

(2) Due to deposition in fissures by infiltration of solutions from the wall rock.

(3) Due to irregular replacement of dunite by circulating solutions.

A Magnetic concentration test of banded *Quartz-iron-ore* from the Mysore State.—*By* W. F. SMEETH.

The test showed that these rocks, which consist of alternating bands of quartz and haematite and magnetite, do not readily yield a high grade magnetic concentrate. The original rock contained

$$\left.\begin{array}{l} Fe_2\,O_3 = 40{\cdot}48\ \% \\ Fe_3\,O_4 = 17{\cdot}08\ ,, \end{array}\right\}\ \text{Total Fe} = 40{\cdot}62\ \%$$

$$SiO_2 = 38{\cdot}46\ \%$$

Even on crushing through 60 mesh screens the 1st magnetic concentrate assayed only 59·88 % of Fe with a recovery of only 28·08 % of the total Fe.

The 2nd concentrate—with stronger magnetic field—recovered an additional 1[illegible]·24% of the total Fe and assayed 52·61% of Fe. The remainder was non-magnetic, slime and loss. Adding the 1st and 2nd concentrates together a product is obtained assaying 57% Fe, with a recovery of 44% of the iron contents of the ore, and containing about 15% of SiO_2.

In order to obtain 1 ton of this product it would be necessary to finely crush and concentrate some 3 tons of ore.

It was suggested that the quartz-magnetite ores of the Kunjamala is in the Salem District—which appear to belong to the charnockite series—might yield a much better result.

Note on the Method of Grading the *Iron Ores* for the Mysore Iron Works.—*By* W. F. SMEETH.

The *limonite* ores at present being used are very variable in slag-forming constituents. The alumina varies from 1 to 9% and the silica from 2 to 12%. The ores from the various sections are mined and built into stacks of about 5000 cub. ft.—the stacks being sampled regularly as they are being formed. The ratio of silica to alumina in the various stacks may vary from 3 : 1 to 1 : 2.

The stacks are all numbered and marked on a chart in which the co-ordinates represent respectively the percentages of silica and alumina and some simple instruments were exhibited by means of which it is possible, by a simple mechanical operation, to select each train-load from a number of stacks in such a way that the whole train-load will contain fixed percentages of silica and alumina.

The percentage of silica or of alumina can readily be varied without additional complication or calculation.

Yellow Augite in Andesite.—*By* C. K. KRISHNASWAMI PILLAI.

This very rare mineral occurs as minute grains in the Andesitic dyke running from Boria to Bhadra near the Phopal river, Kathiawar State, India. From its brilliant citron or honey yellow color, nonpleochroism, high birefringence and positive optic character, the mineral has been identified as Yellow Augite. Its refractive index is between 1.65 and 1.74 ; optic axial angle 2 E=74° ; Dispersion $p > v$. It was not possible to isolate enough of the mineral for a chemical analysis.

As far as could be gathered the only other occurrence recorded of this Yellow Augite is in a Shonkinite from the Oden Forest Baden S. Germany. The author Von Wilhelm Fendenberg makes out that the Yellow Augite is the derivative of the grey green augite by the oxidation of FeO.

Section of Medical Research.

President:—Lt.-Col. S. R. CHRISTOPHERS, C.I.E.,
O.B.E., I.M.S.

Presidential Address.

WHAT DISEASE COSTS INDIA; A STATEMENT OF THE PROBLEM BEFORE MEDICAL RESEARCH IN INDIA.

It is my pleasing duty as President to welcome you to this the 5th. Meeting of the Medical Research Section of the Indian Science Congress.

In choosing a subject on which to address you I naturally turn to some matter of general interest and my predecessors have very suitably led the way by devoting their Presidential Address at these meetings to some aspect of Medical Research in India. It seemed to me that it might be of interest to you if I took for my subject the task, or rather perhaps I should say the mission, of Medical Research in India. To do this it is necessary to review broadly the facts regarding the effects of disease in India. Such a review will I hope shew what the ultimate promise of Medical Science is to India; for judging by what Science has done and is doing in so many paths, it seems certain that she will ultimately place in India's hands the means of preventing and controlling the many diseases that now affect her populations.

What are the outline facts regarding the effects of disease among the 360 millions of this Empire? In the title of my address I have expressed this by asking what the cost of disease is to India. I could perhaps have drawn up a kind of bill shewing in crores of rupees what loss is occasioned by disease. But I should like to think that my efforts will be more useful if I record some of the facts about disease in India and trust that the lay mind will be just as able to judge of the cost, not only in sterling but in other ways, as we medical men.

The Indian Death Rate.

To commence with disease causes death; it will be necessary first for us to see what are the salient features of the death rate in India. The deaths in India annually number about 7,000,000 i.e. very nearly the population of greater London. The average rate for the whole of India for the year 1921, using the actual census figures then available, was about 30 per mille. The rates for different Provinces taken separately, however, varied between about 20 per mille for Upper Burma and Madras, where deficient registration may partly account for the relatively low figures, to 40 per mille in the U. P., and 44 per mille in the C. P.

Now all men must die, but it is to be hoped that each will have a run for his money, so to speak, and live to a reasonable age, say 50 years. Let us see how many of the 360,000,000 of India enjoy this privilege. During the first year of life the expectation of life as given in an actuarial table in the census is for males about 23 years. At the age of 5 it is 35 years, the highest expectation at any age. At 20 it is 27 years and at 50 about 14 years. The expectation of life for females is not very different. How do these figures compare with those of European countries? The total death rate in Great Britain in 1911-15 was 13·8 per mille. The expectation of life in the first year of life for males was about 44 years, and this expectation rose at the age of 3 to about 54 years, the highest point reached. At 20 it was 41 years and at 50, 19 years. We may say then that disease costs every one of the 360 million persons living in the Indian Empire, on the average, a loss of 44-23 or 21 years expectation of life in the first year of life, and 54-35 or 19 years at the age of 3-5 when the dangers of early infancy have already been passed. Every young adult of 20 stands to lose 14 years expectation of life and every man of 50, 5 years. It is true that at the age of 50 the difference does not sound very great; but whilst in England 530 of every 1,000 persons born have reached this age, in India only 186 have done so, so that for every man of 50 in the Indian population who expects to live 14 years there should have been, had it not been for additional liability to disease, no less than three men each expecting to live 19 years.

An increased death rate then is not merely a figure in a book; it is the first penalty India pays to disease, viz. a decreased expectation of life to all the living.

We might claim that the natural life in India is a shorter one naturally, but the curve of death does not support this view to any great extent. We have seen that at the age of 50 the expectation of life in India is 14 as against 19 years in Europe; at 60 the difference is even less i e. 10 against 13, and at 70 it is 6 against 8, and at 89, 3 against 4·6 only. At the most then the chances of a person who has reached these ages is not very different in India to what it is in Europe; the real difference is clearly due to the incidence of disease acting in earlier periods. It is disease then that reduces expectation of life to about half what it is in those countries where the standard of disease prevention and control is what it is in Great Britain.

Death from epidemic disease.

What is the cause of this enhanced death rate? I think a large part of it is due to the fact that India suffers more than

Europe from epidemic disease and more especially from a type of epidemic now practically disappeared from the countries where sanitary methods have reached a certain level of effectiveness. When we speak of epidemics of disease in India it is doubtful if those at home at all appreciate the magnitude of the phenomena we are referring to. The term epidemic is often used in the sense of an outbreak, and one may hear of an epidemic in which say 50 cases of typhoid have occurred as a result of contamination of a milk or water supply. Instances of serious epidemics quoted in text books are the Maidstone outbreak in 1897 where 1900 people out of a population of 35,000 were attacked with typhoid, and a similar outbreak at Lincoln in 1905 when 1000 cases occurred in a population of 51,000. Perhaps the most notable one was the great cholera outbreak at Hamburg in 1892 in which there were 17,000 cases. These are epidemics of a local character, affecting a town or local community, and may be described almost as accidental; they are not comparable at all as regards area involved or populations affected with the colossal manifestations of epidemic disease with which we are familiar in India.

In 1908 in the Punjab there was an epidemic of malaria that could be mapped out by lines of equal death mortality like a cyclonic area which affected simultaneously a population of perhaps 20,000,000, involved an area of some 5000-6000 square miles and caused in three months some quarter of a million deaths, the death rate rising in the focus of the disturbance to some 300-400 per mille per annum. Another epidemic of the same kind occurred in 1892 and in fact similar epidemics have occurred in this part of India every eight years or so as far back as our records take us. A very curious feature of these malaria epidemics is that when mapped out, as they can be by lines of equal mortality (Isothans), they shew a central area or focus where conditions are at their worst and concentric zones of diminishing effects as this focus is departed from. The 1908 epidemic was really two epidemics with two distinct foci; the 1892 epidemic in which there were fully as many deaths was a single epidemic and the largest epidemic of the kind probably ever recorded in medical history.

Epidemics of this magnitude are, however, by no means confined to malaria. Immense cholera epidemics have been of frequent occurrence. They are ascribed to infection carried by pilgrims returning from the pilgrim melas at Hardwar and such like places; but there must be something more at the back of them than the mere fact of such dissemination, some condition peculiarly favourable to the spread of cholera in such years. These epidemics of cholera have not been mapped in the method I have shewn you in respect to epidemic malaria, but from what I have seen of the statistics I believe they also would shew the same focal character as did the two epidemics of malaria whose distribution I have illustrated. Plague formerly almost decimated Europe; it is still present in India and has as we well know its storm centres. Recently Relapsing Fever has been shewn to have far greater importance as a major epidemic disease than had hitherto been suspected. It would appear from the work of Gill in the Punjab that something like a huge epidemic of relapsing fever of a slow and insidious kind is forming over a large part of the Punjab, and Cragg's work in the United Provinces shews an almost similar state of affairs. Had we some method of photographing mortality telescopically from the Moon we should find that these various epidemics appeared as great splashes of abnormal mortality, often shewing a focus of especial intensity covering hundreds of miles of country.

The word epidemic applied as it is to outbreaks of disease on a small scale does not sufficiently characterise such vast exhibitions of the power of zymotic disease and I propose to call such phenomena "Zymonic" from their likeness in distribution to cyclonic disturbances in the atmosphere.

With these few words on a form of epidemic manifestation that we shall have always to bear in mind when dealing with Indian death statistics we may now turn to the estimation of the amount of the total death rate in India due to actual epidemic conditions, for it is clearly of considerable importance to distinguish as a practical matter the liability of a population to sudden and widespread epidemics from its liability to more diffused and general causes of death.

Turning to the causes of death from epidemic disease we find the following number of deaths noted against each recorded cause in the sample year 1921, which I have taken as the last year for which figures are available in the Public Health Commissioner's Annual Reports.

Cholera	450,608
Small Pox	40,446
Plague	69,682
Dysentery and diarrhoea ..	229,576
Respiratory diseases	334,103
Fevers	4,761,237
All other causes	1,499,460

Of definitely epidemic disease excluding malaria there is therefore a total of recorded deaths of about 600,000, another 200 thousand for dysentery and diarrhoea and some 300 thousand for respiratory diseases, or a total for all these causes of something over a million out of the seven million total deaths. Compared with this is the colossal figure of nearly 5,000,000 deaths from fever.

As you know much speculation exists as to the proportion of the fever deaths that can be ascribed to malaria. The data from a recent attempt to arrive at a solution of this problem in the different provinces are given in the last report of the Public Health Commissioner. These data do not generally modify the delegation of a vast total to malaria; the totals are as follows:

Enteric	47,822
Measles	11,738
Relapsing Fever	7,752
Kala Azar	1,887
Other fevers	739,989
Malaria	1,852,391
Total ..	2,661,379

About 70 per cent of the total is still here returned as due to malaria Lt. Col. Leslie in his Presidential Address at the Imperial Malaria Conference at Simla in 1909 makes an estimate from special enquiries, dispensary report and other sources that about one fourth of the total fever deaths are due to malaria. At present I do not think any estimate can be formed as to the part played by malaria in the causation of mortality in India. It is a subject of very great importance the discussion of which must be left to some future occasion. It seems pretty certain, however, that the term "fever" is merely a great residuum of undiagnosed causes of death and for the present we must leave it at that. We have no knowledge at all what proportion is actually due directly or indirectly to malaria, nor even by what types of death in such a vast population malaria exhibits such mortality as it may cause. That malaria is the most important cause of mortality in India is scarcely to be doubted and it is much to be deplored that we know so little about this important aspect of malaria.

Regarding the recorded deaths from other epidemic diseases there are also very important points to be considered before we can say that the figures really represent the full effect of such diseases on total mortality. Attempts have been made in several directions to gain more information as to the true cause of death in India. Increased accuracy of registration of the cause of death is one of these. Another is the verification by sample observations of the actual causes of death in particular areas. I shall not enter into a discussion of these methods which belong more especially to the province of Sanitary Science, but shall take a more general scientific view of the matter.

Not infrequently one hears disparaging remarks about the accuracy of Indian death statistics. The important matter is, however, not to confuse two entirely distinct things, namely the return of death as such and the return of the supposed cause of death. The cause of death is a matter of opinion and it will still remain largely a matter of opinion even when death certificates are signed by medical men, unless they are verified by post-mortem and even then secondary causes might be given which were not entirely or primarily concerned. In the fact of death, however, we pass beyond opinion to exact observation, however ignorant the recorder may be, and it is to the record of the fact of death in India that for the present we must turn in all critical work on the effect of disease on mortality. This is a most important consideration not sufficiently realised in the study of Indian statistics.

As the massed records from a huge country necessarily mask by the multiplicity of conditions involved much that is plainly seen when dealing with records from smaller areas it is usually necessary, to obtain any results of value, to study separately the returns from comparatively small units. Suppose then, as in making a temperature chart we plot the monthly number of total deaths for some registration unit over a period of some years. We shall then get the kind of chart I am shewing on the screen. We may call such a chart a *thanatograph* from the Greek θανατος death and γραφω I write. You will see that we have a tracing such as Science has frequently to unravel, a tracing remember based on observations as reliable as those in most scientific experiments, for we are concerned only with the fact of death and with no one's opinion as to the cause of death. The curve may be likened very aptly to a seismographic tracing. It is like a seismographic record too in that it shews every now and again violent oscillations comparable to records of earthquakes. Looking at the thanatograph we shall see, unless the earthquake shocks are too frequent, that there is a varying but more or less constant number of deaths over considerable periods, but that this even course is now and again disturbed by sudden rises in the graph. These rises are the effects of epidemics, usually zymonic in character. Clearly each rise tells us the number of deaths due directly and indirectly to the influence of the epidemic causing the rise.

Now it is most important fact that you will not find in the statistics enough deaths recorded under any epidemic disease to account for, or nearly to account for, any of these rises. All that you may find is a number of deaths recorded from some epidemic disease that may give you the clue to the interpretation of the total death curve. Frequently it is only from the towns, headquarter tahsils, or places where there are dispensaries etc., that any deaths are recorded as due to this particular epidemic disease. Yet even such information is not always necessary to enable us to interpret the curve. Looking at the rises you will see that they differ in height and in shape; some are short sharp stabs, others long drawn out mounds and every now and then you may see a characteristic truncated cone. Again you will find that each kind of rise has a very strict relation to the time of year. The truncated cones, for example, which are caused by epidemic malaria invariably commence in September and end in December. The short stabs in July or August are due to Cholera. By the characters of its curve and the time of its occurrence many of the epidemic diseases write their records so unmistakeably that with due knowledge it is possible to read from the curve of total deaths what is happening, even when we have no other statistics.

The height to which the rises extend usually depends on the position our special area occupies in regard to the zymonic disturbance causing the rise. If we were to prepare and examine the thanatographs of a large number of registration units lying near one of these death storms we should find that practically all shewed simultaneous rises, but whilst in some that lay in the outskirts of the storm the rises would be insignificant, in those situated towards the zymonic centre the rises would be much greater, the death rate being sometimes 10,20 or even 30 times the normal.

What the proportion of the total death rate in India from epidemic disease may be I cannot say, but it must be very much greater than the recorded deaths from epidemic disease would indicate.

Summarising then we can say that one cause of the high Indian death rate is the prevalence of zymonic manifestations of epidemic diseases. In this the conditions in India differ from the present conditions in Europe, where, except under very unusual circumstances such a form of disease prevalence does not occur.

Almost coming under the phase of zymones were the famines that once decimated tracts in India. Fortunately these no longer figure on our list as direct causes of mortality.

Endemic disease.

Increased liability to death from epidemic disease, though it is an important, perhaps the most important cause of the high Indian death rate and small expectation of life is by no means the only reason for this phenomenon. India being a tropical country not only suffers from some of the most serious diseases of temperate climates such as tuberculosis, but has a long list of infective diseases special to the tropics. Of such diseases we may mention Ancylostomiasis, Filariasis, Leprosy, Dysentery and so on. Certain non-infectious diseases are also peculiarly prevalent in India such as various deficiency diseases, diabetes etc. In the aggregate, the number and variety of these causes of death must be very serious, and liability to them is part of the reason for a shortened expectation of life.

There is still a great deal to be done in the investigation of such forms of disease, the importance of which is only second to that of the great epidemic diseases.

Sickness.

So far we have spoken only of death, measuring disease in proportion to the number of deaths it has caused. But not only is every epidemic responsible for sickness as well as death, but there are many causes of sickness that we have not so far included in the causes of death. In the aggregate the amount of misery from various sicknesses and the amount of incapacity from various minor forms of disease in an ordinary Indian community is extremely great. I have seen the whole of the inhabitants of a small remote village covered with suppurating spores from itch, from which disease they had no means of escape. The number of eye infections and blindness from various causes must strike every medical man visiting the villages. In the streets of Madras and no doubt other towns in the South of India you may see any day half a dozen cases of elephantiasis. Skin infections are a great cause of misery. Of great importance is the role of such diseases as malaria and ancylostomiasis in causing anaemia. In the examination of a number of adults not obviously suffering from disease and in the active list of workers on a large mine I found the percentage of haemoglobin only about 70 per cent of the normal, and such a degree of reduction I suspect is not at all unusual in Indian communities. The fact that some 50 per cent at least of the whole population of Southern India harbour a certain amount of ancylostome infection whilst some 25 per cent shew micro-filariae in the blood are important facts.

That so much sickness must be paid for in some form, either by loss to the individual or in loss to the community is clear. What the amount so to speak to put in the bill may be is, however, very difficult to estimate. In a community of selected healthy adults such as the Indian troops the admissions to hospital for sickness in proportion to deaths as shewn in the statistics for the five yearly period 1915–19 is about 50 to 1, whilst the proportion of constantly sick to deaths is about 2 to 1. For 1,000,000 deaths representing in round figure annual deaths among adult males of 15-50 years of age in the general population there should be on the above basis at least 2 million constantly sick and the equivalent of 50 million admissions to hospital. We know from the Census returns that there are in India at least 80,000 insane, 200,000 deaf mutes, 500,000 totally blind and 130,000 lepers sufficiently pronounced to be returned as such.

All this is very difficult to put down in terms of wages lost by the individual or wasted to the community but it is nevertheless a payment definitely made by India.

The Economic and Financial aspect of disease.

So far we have dealt only with disease from the point of view of the person affected or his family or others dependent on him. There is, however, an outlook which may be called the economic in which Government especially may be expected to be concerned and another view the financial in which both Government and various other bodies are concerned. We may briefly consider one or two obvious points in this connection.

Increase and decrease of population.

In the decade 1901-1911 the net increase of the total population of India was 6·4 per cent: in the decade 1911-21 it was 1.2 per cent. But whilst these figures represent at least some increase for India as a whole, examination of the data for particular areas shews that whilst some areas have shewn an increase others have not only not increased but have shown a decrease, e.g. the United Provinces, which for some 49,000,000 inhabitants shewed a decrease 1.1 per cent in 1901-11 and a decrease of 3.5 per cent in the last decade. Again in the Punjab which shewed in 1901-11 a general increase of about 5 per cent, a population of about 13,000,000 occupying an aggregate area of 32,000 square miles had not increased but decreased by 9.7 per cent.

A decrease of this kind in a population like that of India is an ominous sign. There is no question of its being due to a lessened birth rate as it might be in a more sophisticated population, nor is it due to emigration on such a scale, and it must therefore be due to an excessive death rate. But an excessive death rate is not an isolated phenomenon and to every death there has been an equivalent amount of sickness interfering with the normal life of families, preventing the people tilling the ground, or collecting the harvests or tending the cattle on which the welfare of the rural population depends and so forth. It must inevitably mean loss of revenue, loss of general effectiveness of such populations and the deterioration of the resources of the affected areas. The cost of such deterioration could no doubt be assessed, but apart from this it is due to the population so affected that they should as far as possible be preserved from such results, and at this I think we must leave the matter.

Agricultural Advance.

In a country like India no single factor in its prosperity can be so important as the increase of locally grown food supply. Such increase is brought about by improved methods of agriculture but also by bringing new areas under cultivation. The latter method in particular is peculiarly dependent on the absence of serious prevalence of disease. In the great Canal Colonies a serious menace is the malaria that is normally induced as a result of irrigation. At first relatively healthy, such areas are liable to an increasing malarial endemicity that if it does not altogether nullify the good such schemes bring at least detracts largely from this.

In efforts to open up new areas of cultivation again disease may often be the factor determining success or the reverse. In Assam I had the opportunity some years ago of examining a newly opened experimental project for the growing of sugar cane on a large scale. There exists along the foot of the Himalayas in these parts a broad belt of grassland, many hundreds of square miles in extent, almost uninhabited and entirely unexploited. The soil and other conditions agriculturally were said to be favourable and the whole question of the commercial value of utilising the land could be seen to turn upon the prevalence of malaria. When I saw this experimental estate it called to my mind accounts one reads of the operations in the far west. The ground covered with tall elephant grass was ploughed, elephant grass and all, by huge steam tractor ploughs. If a tree grew where it was not required it was pulled up by the roots by the powerful machinery. Whether this venture will be a success and add a new industry to Assam will be a matter of whether man or the malaria parasite wins the day.

Industrial expansion.

Next to the production of food supply in importance to India is the expansion of her industries. Industrial success is largely bound up in the maintenance of effective labour forces, and the factor which determines the satisfactory maintenance of a labour force more than any other is the prevalence of disease. It is the aim of industrial concerns to have a labour force living happily on or near the estate. Very often on account of disease such communities have to be maintained by constant recruitment. The children die, the adults, except such as weather the storm and become old immune hands, suffer from fever and anaemia and the mental consequences of such a state, and the net result is disease and a deficient and ineffective labour force. In such industries also as employ millhands the influence of disease must be ever present reducing efficiency, increasing the cost of wages and limiting profits. We may say that in the matter of Industry disease is not only a tax, but to some unknown extent depending on the industry concerned, a limiting factor to its full and useful development.

Public Administration and Trade.

Not inconsiderable must be the loss to India of increased salaries paid because the world's market fixes its own rates for life endangered by disease, increased expenditure from invaliding, shortened service and increased leave that the world also demands as its price for exposure to disease. Worse still must be the money paid for ineffective service of subordinates liable to frequent sickness or definitely on the sick list. Here should be added also the cost of maintaining the sick, of supplying drugs, of the upkeep of hospitals, lunatic and leper asylums and so on.

As regards the effect on trade a very little experience shows one the part played by disease in limiting and making more expensive all forms of commercial activity. Latterly in Bombay there has been a very ominous increase of malaria in the city itself. Imagine, if one can, an active commercial life in a city subject to a serious prevalence of malaria. In one way or another almost imperceptibly perhaps, but every day and in every way, to parody a popular phrase, disease would oust human activity until there remained only the pallid remnants of once active communities dragging out an existence of temporary exile in a decayed tropical metropolis—like the dreams in some Wellsian romance.

A point of some importance is what a country pays for a bad sanitary reputation. Such a country is apt to be mulcted by health restrictions, sanitary regulations and quarantine applied to its shipping and ports, all entailing delay to commerce and perhaps even directing trade elsewhere. Shipping firms have to maintain agents and to pay them in accordance with the sanitary reputation of the country. Firms have to do the same. All must ultimately be paid for by increased cost of necessaries to the country concerned. A recent bulletin gives the value of India's annual imports as over 200 crores of rupees and that of her export as about 300 crores. A very small *ad valorem* percentage as a result of such influences as we have indicated would very soon run into crores.

This is a modest statement of the case against disease in India. The cost I cannot pretend to put into figures. All I can say is that the tribute paid to disease in a country like India is one of importance economically even politically and one that has many financial and commercial aspects. It, however, transcends this in being of importance to the welfare of 300 million human beings, who by their tacit acceptance of such calls as may be made upon them signify their belief that they are being governed to the best ability of those responsible for such Government. The important matter therefore seems to be that proper and enlightened views should be held by Government as to the steps to be taken to justify that trust in so far as the prevention and amelioration of disease is concerned.

But no Government however enlightened can combat disease without knowledge, and were they prepared to lay out vast sums on the public health their efforts would be nugatory without the contributions of Medical Research. Both sanitation and medical relief are based on the findings of Medical Research and are powerless to advance except as a result of advances in the branches of Science dealing with disease. The vastness of the problems at issue cannot be ignored. It is no question of applying such knowledge only as we now have, nor of purchasing the necessary knowledge from Europe. Europe cannot help, for her problems are different and she knows nothing of India's requirements. Only by the encouragement of research in her own territories can India arrive at a proper basis for effectively combating the many diseases that affect her populations and it is the duty of an enlightened Government to allocate a due proportion of her revenues to this purpose.

There are many aspects of Medical Research and the proper proportioning of the activities of a department responsible for such research is a problem in itself. Highly technical studies are necessary as well as more obviously utilitarian activities. What is important is that those concerned in research should be inspired by the flame of active endeavour. Things have so worked out that latterly much of the medical research work in India has been fostered and financed by the Indian Research Fund Association. Experience has shown that such an organisation works well and with the recently instituted Meeting of Research Workers to voice the views of those actually carrying on the work, a most useful directing force is assured. A good deal has been heard lately of the control of research, but what is needed now is not so much the prevention of some possible overlapping of researches, a matter of little moment, but a greater volume of good class work and especially sustained research on some of the major diseases of India.

Fifth Paper on Filariasis.—*By* P. N. Das.

I. *Filarial embryos in Lymph and Blood.*

Rudimentary structural growth of M. F. in blood.

II. *Investigation into the prevalence of Filariasis among Birds and other Animals.*

Pigeons, Sparrows, Rabbits—all found negative so far.
Horses and Dogs found positive. Filaria rate, etc., among animals.
Anatomical features of Animal Filaria as compared with Human filaria. Discussion.

III. *Water-borne theory of the propagation of Filariasis.*

IV. *Influence of Toxins on M. F. in blood in cases of Filariasis.*

Cholera, Uraemia, Pneumonia, Malaria, Kala-azar.

V. *Filarial Periodicity.*

Two recent fascinating theories:

(*a*) Vibration of the sheath of the embryo and detachment from its resting place in the lungs in response to the "pitch of fundamental note" produced by culex.

(*b*) Negative Heliotropism.

Our observations show that in heavily infected patients, M.F. may be found at any time of the day in peripheral blood. The deposit of centrifugalised blood drawn from a superficial vein would also show the presence of M.F. at any time of the day. The subject requires further investigation.

VI. *Certain features of Chyluria and Lymphorrhagia.*
Lymphuria, Haemato—Lymphuria.

Development of fever and melancholia after the healing of the wound following operation for Lymph Scrotum. 31 c.c. of solution of Sodium Antimony Tartarate had no effect on Chyluria.

VII. *Treatment of Filariasis.*

Removal of Scrotal Tumours (Elephantiasis) by surgical operation was followed by Elephantiasis of the leg in six cases within 1 to 3 months and in one case by recurrence of Elephantiasis locally and Chyluria. There was recurrence of Lymphorrhagia in one case after operation for Scrotal Elephantiasis. When a large lymphatic area is cut off, the ova and the embryos may be expected to flow into the neighbouring available lymphatic areas—lower extremity, pelvis or both—from the next breeding period after operation. As the breeding of the adult filarial parasites takes place at least once a month, it is conceivable that Lymphangitis of the leg may follow a month after operation. The futility of surgical operation in preventing the recurrence of Elephantiasis is obvious and emphasises the necessity of following up the operation by Antimony intravenously.

In 1923, 92 cases of Filariasis which included 8 cases of Periodical Filarial Fever, 3 Filarial abscesses, 48 cases of Lymphangitis, 33 cases of Elephantiasis, 4 Orchitis, and 1 Chyluria were treated by Antimony intravenously, 69% of Lymphangitis, 64% of Elephantiasis were in the leg, the rest in the Arm, Penis and Scrotum. 28% of the total number of cases treated were below 20 years, 50% below 40 and 22% above 40. 68 came from the Town and 24 from the interior of the district.

We stick to our observations recorded in the previous paper regarding the effect of Antimony intravenously upon the Elephantiasis of the limbs Restoration of the limb to its normal condition occurs in cases of Elephantiasis where the limb is soft and pits on pressure and considerable improvement in the advanced stages when the limb is hard from the development of Fibrous Tissue.

Plague Rat Engineering.—*By* V. D. Pillai.

Mr. Barklay wrote a book in 1892 on rat training. He says there the number of young produced at a birth is on an average fourteen. Thus rat catching and rat killing of such a prolific animal cannot, in the face of it, be an effective remedy.

Rats have brains and a language. If you catch them, annoy them, fast them, and then let them go without killing (like prisoners in a jail are trained and let off after their term is over) the rats so treated will form a committee, discuss and decide and at once quit human dwellings. The other effective methods are fumigating rat holes with sulphur, removing all relic or refuse food outside dwelling houses, and proper and suitable drainage contrivances between the house and the street, with a water seal where the drainage system is not perfected. Since writing the above paper, a very clever, cheap and efficient contrivance has occurred to me, by which any house in India could be fixed with a water seal, and a gulf made between man and rat. Any Corporation or Municipality may apply to me for full details and other particulars, through the Chief Engineer and Secretary, General Branch P.W.D., Hyderabad, Deccan.

A simple method of preparing a series of tenth dilutions.—*By* S. N. Goré.

In a paper read by Colonel Liston and the author at the Indian Science Congress in 1918 a simple method of preparing a series of dilutions by tenths was described. A still simpler method is now described. The only equipment required consists of a few hollow ground glass slides, 2 platinum loops, one 5 mm. and the other 1 mm. in diameter. These, made in the manner described in the previous paper, take up approximately $\frac{1}{40}$ and $\frac{1}{400}$ of a c.c. respectively when biconvex loopfuls are removed. Dilution is made by marking and serially arranging on the table as many hollow slides as the number of required dilutions. One loopful of the 5 mm. loop of normal saline is placed in the hollow of each slide. A loopful of the 1 mm. loop is then taken of the culture or faeces suspension and thoroughly mixed with the saline in the first hollow; without sterilising the loop a drop of the first mixture is carried over to the second slide, and after mixing, one from the second slide to the third and so on to the required number of dilutions. The loop is now sterilised and cultures made on agar with a loopful starting from the highest dilution.

A simple method for detecting and estimating Indican in urine by means of the cotton wool plug test. (Preliminary note).—*By* S. N. GORÉ.

Obermeyer's test, which is based on the principle of effecting the decomposition of indican in the urine and oxidation of the indoxyl set free to indigo-blue, though simple does not meet all the requirements of a routine test. It is now shown that the cotton wool plug technique devised by the author primarily for applying Ehrlich's reaction to detect indol in sputum, can also be used to determine indican in urine, and is more simple, rapid and economical in reagents than Obermeyer's test. The test can also be used quantitatively. For the test 2 c.c. of urine are intermittently boiled in a tube with an absorbent wool plug moistened with potassium persulphate and p-demethylamidebenzaldehyde solutions. If indican is present the under surface of the plug turns pink. Quantitative estimation is made by applying the above procedure successively to each of a series of half dilutions of the urine until only a just distinguishable pink is succeeded by no colour at all.

A simple method for the classification of aerobic bacilli growing well on ordinary laboratory media and for the provisional identification of certain intestinal bacilli and vibrios.—*By* S. N. GORÉ.

The existing schemes of classification divide the bacilli of the typhoid-colon group into 9 to 12 subgroups on the basis of their fermentive reactions and of motility and capsules, the number of media required varying from four to eight. None of these schemes include indol or carbinol reactions.

A simple method is now given of dividing the typhoid-colon group and other related bacilli into six groups and 48 subgroups by the use of only 3 media, viz. glucose, lactose and peptone. In glucose culture are ascertained the absence or presence of partial or complete fermentation and of carbinol (Voges-Proskauer) reaction; in lactose culture the absence or presence of partial or complete fermentation; in peptone culture the absence or presence of indol and of motility. The six groups are based on fermentative reactions in glucose and lactose and the further subdivision in 24 groups on indol and carbinol reactions. The final subdivision into 48 groups is based on motility or non-motility in each of the above. In recording the result positive reactions are indicated by suitable capitals, partial fermentation by small letters, and negative reactions by zero, thus giving a subgroup formula. This system has been applied to certain aerobic non-spore producing intestinal bacilli tabulated by Castellani with the result that a key has been presented for the classification and provisional identification of these bacilli.

A note on the value of prophylactic inoculation in the prevention of chronic carriers of typhoid and paratyphoid bacilli.—*By* J. A. CRUICKSHANK.

The diagnosis and control of chronic carriers is arranged for in the Army by sending all convalescents to an Enteric Depôt for bacteriological examination, chronic carriers being invalided out of the service. In England the Public Health Authorities have certain powers to enable them to deal with carriers It is the chronic carriers by whom these diseases are perpetuated, the temporary convalescent comparatively quickly ceasing to excrete the bacilli.

It was thought that prophylactic inoculation might have some effect on the production of chronic carriers and records were examined to see if this view held good. These included records of 1000 soldiers convalescent from dysentery and enteric in England in 1917 given by Fletcher and records of 1886 men convalescent from enteric group fevers collected by myself and Mr. LaFrenais. In the former none of the eight chronic carriers had been inoculated with triple vaccine. Among my own series 3·2% of chronic carriers were among the uninoculated and 0·5% among the inoculated. The percentage of chronic carriers among those inoculated with simple typhoid vaccine was 0·56% all of whom were carriers of B. paratyphosus A.; 0·3% of those inoculated with triple vaccine became chronic carriers.

Only three of the twelve undoubted chronic carriers had been thoroughly and efficiently inoculated, showing that efficient prophylactic inoculation has the effect of reducing the number of chronic carriers resulting from an epidemic of typhoid and paratyphoid fevers.

Some Himalayan and Peninsular Varieties of Indian Species of Anopheles.—*By* S. R. CHRISTOPHERS.

Two species of Anopheles, *A. gigas* and *A. lindesaii*, occur in India only at considerable elevations. The former species usually at 6,000 feet or over. These two species are found throughout the whole length of the Himalayan Chain, but they are also found in the high plateaus of Southern India, separated from the Himalayas by some thousand or more miles where suitable conditions for them do not occur.

The species *A. simlensis* from the Himalayas was originally founded by James mainly on the fact that this had banded palpi, whereas the Southern Indian form was supposed to have unbanded palpi. This distinction was found, however, not to hold good and *A. simlensis* was not considered a separate species in my revision of the Indian Anopheles in 1916 Since then a great deal of material has been collected from a wide range of localities and a close study of this has shown that in the case both of *A. gigas* and of *A. lindesaii* specimens from the Himalayas can be distinguished by certain characters from those from Southern India. *A. gigas* (type form) occurs in the Nilgiris, Kodaikanal Hills, etc. *A. gigas* var *simlensis* with pure white markings on the palps, a double dark spot on the outer portion of the costa, absent or poorly developed fringe spots and a spot or band on the mid femur on the other hand is found from Kashmir to the Shan States in Upper Burmah. In the case of *A. lindesaii* the type form with the hind femur pale beneath and a pale spot on the ends of veins 3 and 4·2 occurs from Abbotabad to Darjeeling, while the southern form *A. lindesaii* var. *nilgiricus* var. nov. with femur dark beneath and no pale spot at the ends of veins 3 and 4·2 is found in the Nilgiris, etc. *A. lind.* from Japan has the characters of the northern form which thus probably extends throughout the highlands of Central Asia.

A. asiaticus described from the F.M.S. has not been recorded from India and the species representing it is *A. annandalei*. *A. annan.* occurs in the Eastern Himalayas and Assam and as shown by specimens sent as *A. asiaticus* from Ceylon by Col. James many years ago also in Ceylon.

Further observations on Tubercle bacilli subjected to Autolysis with special reference to the antigenic value of their lipased products.—*By* R. Row.

A digest with petroleum either of a mass of tubercle culture self-digested for several weeks in a medium of normal saline yields 3 layers. The topmost layer consists of petrol ether which has taken up the lipased products of the fatty or waxy components, the second layer is made up of agglutinated more or less altered tubercle bacilli and the third layer which is unimportant consists mainly of the normal saline in which the autolysis was allowed to proceed. The first layer suitably treated yields a colloidal solution suitable for serological investigation, but compliment fixation tests with this as antigen invariably yielded negative results and for this and other reasons further study of this layer was abandoned. Compliment fixation with a product obtained by repeated washings of the second layer, after drying, with xylol yielded a positive result. Rabbits and guinea-pigs treated with this product showed little or no local or general reaction and treated guinea-pigs when infected with live and virulent tubercle bacilli shewed a definite immunity either partial or complete. The use of the above antigen has been applied to a few cases of glandular and pulmonary tubercle in man with beneficial results in some of the cases. Of the eight cases of glandular tubercle four have shewn distinct local as well as general improvement, and three cases of pulmonary tubercle who persevered in a long course of weekly injections shewed remarkable improvement.

Saponification of bodies in the United Provinces of Agra and Oudh.—*By* RAI BAHADUR J. P. MODI., *and* D. N. CHATTERJI.

Of twelve cases of saponification which came under the personal observation of J. P. Modi six cases are described in this paper. Time required for saponification in these cases varied from 7 to 35 days. It is pointed out that saponification is more common in Lucknow than in Agra, possibly due to some climatic variations. The saponified tissues in the last two cases of the series did not show any definite structure under the microscope except masses of acicular crystals and round bodies consisting, in all probability of neutral fat and soap. Chemically these substances consisted of a minute quantity of lime soap, free fatty acids, viz., palmitic and stearic acids, unsaponifiable matter and the ash contained lime, soda and potash compounds.

Oedema.—*By* W. BURRIDGE.

There are two kinds of œdema, the one without effect on functional capacity, the other markedly influencing this latter.

Nerve endings are especially influenced by the second type of œdema and this influence would be diagnosed clinically as peripheral neuritis. The results may apply to such tropical diseases as beri-beri etc.

The Existence of Hymenolepis nana infection in India.—*By* SOHRAB H. NANAVUTTY.

A case of infection with *Hymenolepis nana* is described. Characteristic ova were found in the stools. The case, an English child of 8 years of age recently arrived at Bombay from Northern India shewed acute symptoms ending with death, apparently due to malarial infection; but how far cerebral symptoms might have been due to the helminth infection is uncertain. A second case of *Hymenolepis* infection in patient from Northern India with severe anaemia was later seen.

Blindness in India. Its Causes and Control.—*By* S. M. A. Faruki.

1. That blindness amounts to about 1 per cent of the total population of India.
2. That preventable and curable cases equal 75 per cent of this number.
3. That neglected conjunctival disease is responsible for about 60 per cent of blindness.
4. That ignorance and apathy of the people together with lack of medical facilities is pre-eminently responsible for this state of affairs.
5. That it is the duty of the Government to provide adequate medical facilities and that of the medical profession to move the Government in this matter.
6. Economic loss owing to blindness amounts to at least 15 crores of rupees per year.
7. Resolution asking the Government to appoint a commission of enquiry with blindness is suggested.

Further observations on latent dysentery.—*By* J. Cunningham, *and* J. H. Theodore.

Latent Dysentery was first investigated in the jail populations of Eastern Bengal. Opportunity for extended study of this subject has occurred in the Madras Presidency. The investigation which has been carried out recently corroborates in the main the observations noted in Eastern Bengal and again emphasises the great importance of recording this type of dysentery.

Recent methods of differentiating Lactose fermenting organisms, as applied to Indian conditions.—*By* J. Cunningham *and* T. N. S. Raghavachari.

Investigations by American bacteriologists followed up by bacteriologists in England during recent years, have shown that lactose fermenting organisms can be divided into two very definite types based on the ratio of Co_2 to H_2 produced by them in special buffered Glucose media, and that the concentration of the Hydrogen ions effected by these two types can be determined colorimetrically by means of a suitable indicator (Methyl-red) with a considerable amount of accuracy. These investigations have proved that the high ratio type (Methyl-red – V.P. +) are rare in human and animal faeces more common in surface water, milk and sewage and the predominant type in soil and grain.

The present paper deals with an investigation carried out by the authors between 1921 and 1923, on 960 strains of lactose fermenting organisms isolated from human faeces, 200 from bovine and 3066 cultures from the water supplies of the Madras Presidency (both raw and filtered). Our findings agree in the main with those of the American and English workers as regards human and bovine faeces and water samples. Certain minor points of difference with regard to the biochemical reactions, which were noticed, are discussed.

A few points on the Etiology of skin diseases met with in the Tropics.—*By* G. Panja.

In the skin out-door department of the Calcutta School of Tropical Medicine and Hygiene a unique opportunity is afforded for the study of many of the skin diseases met with in the Tropics. The sex factor is important in the aetiology of some of them Tinea cruris and Mangoo toe are seen more often in males, whereas Lupus erythematosus and skin diseases due to friction of ornaments, etc , are noticed in females.

Unmarried young girls with leucoderma form also a large per cent of our cases. As regards race, Tinea imbricata is very commonly seen amongst Uriyas and Boatmen ; elephantiasis of legs in Anglo-Indian girls and Scabies and folliculitis among the Jews. Habit and dress also play an important part in the aetiology. Folliculitis of lower legs is very commonly seen in patients who wear dhutis. This sets up a continuous friction on the hairs of the parts. Shoes without socks cause dermatitis along lines of pressure. Corns, Keratoma plantare sulcatum and Hyperkeratosis are seen in barefooted persons. In Europeans, the friction of clothes on the axillae and the pressure of boots keeping the outer toes in close apposition favour the development of axillary boils and mangoe toe respectively. Favus is commonly met with in the Frontier as the people are in the habit of putting on one another's headcaps. The different forms of trade dermatitis amongst nurses, varnishers, jute mill workers, etc., have come under our observation. The prevalence of Oriental Sore in Bombay and Delhi, Yaws in Ceylon and Burma, Infective Granuloma in Madras and the Himalayas, Elephantiasis of the legs in Bengal and several other diseased conditions are closely associated with the factor of climate. The climatic factor is also very important in the prevalence of leprosy in the tropics. Certain skin diseases are closely related to seasons. Staphylococcic infections and seborrhoic dermatitis are more commonly seen in the hot months ; ringworms during the rainy season and streptococcal dermatitis and psoriasis in the winter. Idiosyncrasy to foods and drugs giving rise to urticaria and drug eruptions has been studied by us. As in other diseases, diathesis plays a part in the hyperpigmentation of kala-azar, sclerodermia, tuberculides, carbuncles, etc., Some skins are particularly liable to diseases. The occurrence of acne vulgaris in oily and coarse skins and ringworm in fatty persons has often attracted our attention. The characteristic skin rash of dengue is probably known to many. The parasitic fungi invading the skin have up to the present not been sufficiently studied, so that they have been grouped under the terms—ringworm, seborrhoea, and blastomycosis. The old term Eczema which has hitherto been employed in text books, we have now replaced by the more exact nomenclature—Streptococcal dermatitis.

Experimental Studies in Bilharzia Therapy (*S. spindalis*) A Preliminary Report.—*By* N. HAMILTON FAIRLEY.

In Bombay there exists a species of mammalian Bilharziosis (S. spindalis) which can be readily conveyed to goats. Nearly 100 of these animals have been artificially infected the present preliminary report dealing with 30 of these, 19 of which have been treated with Tartar Emetic, 6 with Urea Stibamine (Brahmachari) and 5 with Emetine Hydrochloride in all cases by intravenous injection into the jugular vein. The general concensus of clinical opinion is that tartar emetic exerts a markedly beneficial effect in human schistosomiasis, but in 15 out of 19 animals in the author's series worms were demonstrated at autopsy in the portal or mesenteric veins or both and ova were demonstrated in the tissues in 16 of these cases, in at least 9 cases motile miracidia being demonstrated in ova in the bowel wall. Positive compliment fixation developed in all the 19 cases, this reaction being converted from a strong to a weak or negative reaction in those animals where post mortem examination had revealed cure. In 11 out of the 19 cases tartar emetic definitely failed to cure and appeared to exert little if any influence on the course of the disease. No evidence was obtained that urea stibamine exerted any beneficial therapeutic action in S. spindalis. Of 8 animals treated with Emetine Hydrochloride the first three died from over dosage, the correct dosage being subsequently estimated as 1 c.c. of a 1 per cent solution for animals not exceeding 25 lbs in weight. The rapidly lethal effect of intravenous emetine hydrochloride on adult schistosomes in the venous system was remarkable. In two animals autopsied on the 111 and 125 day all worms had completely disappeared. In two others examined on the 13th day all worms were dead and in different stages of degeneration. In the last animal 39 out of 40 worms were dead the survivor worm being a male. Direct microscopical examination of the bowel wall and of scrapings of the mucosa showed only dead ova in two animals. In the animals examined on the 111 and 125 day no ova were present. In the animal in which a living male was found some ova containing living miricidia were observed. Strongly positive compliment fixation had developed in all 5 animals, this was unmodified in the animals sacrificed shortly after treatment had commenced but had become negative in the two examined after a lengthy interval.

On Spider-lick, a Dermatozoosis.—*By* C. STRICKLAND.

A condition is not uncommonly seen in some parts of India, as in Assam, of an escharmosis which is sometimes severe and may lead to destruction of the dermis. It is often associated with considerable swelling and sometime troublesome and even alarming sores may develop. The popular notion, expressed in the name locally given to this condition, that the effects are due to a spider, has not been upheld by investigation. The cause of the condition in Calcutta and Assam appears to be a common Staphylinid beetle *Poederus fuscipes.* The insects allowed to crawl on a skin surface produced no effect even when harried, but rubbed on the skin erythematous papules, followed in one case on the second day by vescicles, were obtained. A popular and vescicular eruption was obtained by the use of an alcoholic extract of the beetles.

Laboratory Notes on a series of 15 cases of Infantile Cirrhosis.—*By* P. PARTHASAWATHY.

Certain cases of infantile cirrhosis of the liver examined by liver puncture and post-mortem shewed round oval or lemon shaped bodies yeast like or resembling ascospores. Mycelial threads were also seen in sections.

Section of Anthropology.

President:—Rao Bahadur L. K. Anantakrishna Iyer, B.A., L.T., F.R.A.I.

Presidential Address.

PRIMITIVE CULTURE OF SOUTH INDIA.

Introduction.—The existence of primitive men is based more on speculation than on the investigations of primitive culture. The study of Primitive Culture itself arose from the study of the culture of the 'present-day man.' The primitive man is supposed to be one who is devoid of the attainments of culture. He is the savage, who is no better than an animal, endowed with a few human qualities, with the rudiments of language and reason just sufficient to tide over his deplorable condition. "Man in his natural state," says Thomas Hobbes, "lives as an animal with his fellow beings, among animals in a struggle for survival." His rudimentary culture is a contrast to that of the civilized man. The conception of Hobbes and his contemporaries that he is on a level with the animals of the forests around him has been considerably modified by Rousseau, and others according to whom man in a state of nature, lives a contented and peaceful life unfettered and free from want.[1]

Definition of Culture.—By culture in the widest ethnographic sense, is meant that complex whole, art, belief, morals, law, custom and other capabilities and habits acquired by man as a member of society.[2] Here we are concerned with the primitive tribes whose achievements to satisfy the most urgent needs of life, consist in providing themselves with clothing, seeking after food, making their implements and weapons for protection and self defence. In the domain of culture he utilizes the resources and properties of products in their immediate physical environment.

Classification of Culture.—For the proper understanding of the character and habit of the primitive man, we have to study his achievements, and the one close at hand is that afforded by external culture which is expressed in dress, habitation, food and in self-made implements and other production serving to satisfy his urgent needs of life. It has been said that all the world is one country, and that one set of savages is quite like another. How far this generalization is true can be shown by an Ethnographic Museum. A Museum of the kind exists nowhere in India except the one in Calcutta, which does not fully satisfy our expectations. We have therefore to study the life history of the tribes first hand, collect the specimens which illustrate their culture, arrange and classify them in proper groups. Until then all attempts to give a correct account of the culture of the primitive tribes must be necessarily imperfect. The chief characteristic of the primitive man is the habit of the mind which is dominated chiefly by tradition, and the savage refers all novel experiences to traditional forms. When they are modified they lose their vigour and acquire the primitive or infantile character which assimilates them. Further all cultures lower and higher have a history behind them. We also find in them survivals which are either harmless or neutral in social value. Each tribal group is a social group having a culture which may differ from that of another, and the difference is due to the varying influence of environment. All consist of men and women having different functions. All need food which they get from the bounty of nature. All raw material of food, clothing, shelter, and implements depend on natural products. Therefore in the examination and classification of the material we have to see how the problem can be stated for and by a social group, and how the solution can be made with due regard to the mental powers of that group and its technical abilities. Complexity of the cultures of South India can testify to it. We are here concerned with that portion of the humanity dwelling in the jungles. They have a history of their own. They may teach us something of the mental development of the human society, for among them are preserved in full vitality modes of thought, in contrast with the spirit of science which seeks to penetrate the secret laws which govern them.

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[1] W. Wundt. Elements of the Folk Psychology. P. 11.
[2] E. B. Tylor. Vol. I P. 1.

Clothing and decoration.—Primitive man was at first in a state of nudity but in the course of progressive evolution he became subject to the sense of shame which was not in him. This sense of shame which is a specific product of modern civilization became more and more a simple manifestation of the male. From this arose the idea of clothing which manifested itself in painting and tattooing. The palaeolithic man was fond of painting, for in palaeolithic times coloured earths were discovered, and coloured pastes were made by mixing iron with reindeer fat.[1] In the history of cosmetics painting is said to have dated from the days of Biblical antiquity, and can be traced back with certainty to the man of ice age.[2] Among the relics of the ancient cave men of Europe are hollowed stones for grinding ochre and other colours for paint-

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[1] Iwan Block. The Sexual Life of our Time.
[2] Do. p. 134. Do.

Section of Anthropology.

President:—RAO BAHADUR L. K. ANANTAKRISHNA IYER, B.A., L.T., F.R.A.I.

Presidential Address.

PRIMITIVE CULTURE OF SOUTH INDIA.

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[1] Iwan Block. The Sexual Life of our Time.
[2] Do. p. 134. Do.

According to Klaatsch palaeolithic man was not satisfied merely with painting, he also tattooed himself with flint knives. Clothing originated in the decorative impulse and its three functions are protection, ornament and self feeling. It is difficult to say where clothing ends and ornament begins. The former stands in unmistakable relation to sexual life. Both painting and tattooing are intended for the purpose of sexual allurement and stimulation. It is also possible that the original meaning of the latter is to be found in the attempts to cover nakedness. Most of the hill-tribes that have come under observation during my ethnographical investigations tattoo and paint their faces and bodies during festivals and in various patterns. Women are profuse in their designs. To the next stage in clothing belong the leafy garments and those of bark. The Mala vedans of Travancore, the Veddas of Ceylon, the Thandapulayans of Cochin, the Vettuvans of North Malabar like the Jwangs of Chota Nagpore, the Sakai and Jakuns of the Malaya peninsula wear leafy garments. The Kayaks of Borneo wear bark cloth. It must be noted in this connection that girdle is the point of departure in the evolution of dress. The civilized idea of it is to bind up a skirt or trousers, and the earliest ones are merely strings made of grass or vegetable fibre. It is a male appendage, and is worn neither very tight nor very loose. The savage needs it constantly to carry the articles which would encumber his hands. Even now the males of any of the castes and females of some wear a cotton silver or gold thread to which a piece of cloth is connected to cover exposure. It serves the purpose of a belt. Closely connected with clothing are the mutilations and deformations, which are also intended to serve the purpose of adornment. The Kadars of the Cochin forests chip all or some of the incisor teeth in the form of sharp pointed serrated cones.[2] So do the Australians. The women have dilated ear-lobes bore the septum, disfigure the lips and adopt various methods for the wearing of ornaments. In fact they require eight kinds of ornaments, namely, ear-rings, nose-rings, necklaces, bracelets, armlets, anklets and toe-rings. Partly owing to their frequent contact with the people of the plains, and partly owing to the influence of the missionaries and work in plantations, their leafy garments have already disappeared or are disappearing in favour of machine-made cotton cloths.

Food-quest.—Food is the urgent and recurrent need of individuals and society. It dictates their activities in relation to their land at every stage of their economic development, fixes their locality for residence and determines its extent from which maintenance may be drawn, and the duration of living thereon depends on the food supply either perenial or intermittent. Considering these facts, the South Indian hills still have evergreen forests, yielding abundance of fruits and tubers, and streamlets producing abundance of fish. There are also animals for their game. Therefore these denizens of the forests choose their residence in localities where they can get their articles of food in plenty. At the outset they depend upon the bounties of nature, and when the supply becomes either insufficient or exhausted they migrate to another portion. So long as they can get their food with minimum labour, they care for no settled habitation. The dietary of the Kadars and Malcers of the Cochin forests and the hill tribes of the Travancore hills consist of the various edible and succulent roots, bamboo seeds, mealy portion of the seeds of the Cycas tree flourishing on the lower portion of the hills; deer, sambur, wild boar, rats, field mouse, and wild fowls. The women go about in small groups with their digging sticks to upturn edible roots, while the males either singly or in groups go for hunting. Both men and women are familiar with every nook and corner. Once when some women were engaged in digging for some edible roots, a grown up bear attacked one of them from behind, while the others bawled aloud. A Kadar who was in the neighbourhood approached the animal, and with his bill-hook despatched him at once and rescued her. The tree-climbing and honey-gathering of these hill-folks evoke the admiration of the people of the plains. In this connection it is interesting to note that some of the hill tribes with whom I came in contact, told me that the forests were theirs, and that the white men and the people of the plains encroached upon their rights to such an extent that no convenient places could be had to live in, and that they found it difficult to procure their food. Consequently they were forced to work for their livelihood. They now work in plantations and under the Forest Department for daily wages. They collect the minor forest produce and give it to the contractor from whom they get rice and other articles of food as also a few rupees to purchase their cloths and other necessaries. The tribes that live on higher elevations have not yet taken up agriculture, while those that live on the hill slopes have adopted a little of it. It is known as terrace cultivation, and is of a migratory nature. The hill tribes all over India are forced to take this up owing to the diminution of edible roots and game, owing to the unwise clearing of forests in these days. This necessitates the children of the forests to seek their abodes either on the lower elevations of hills or at the foot of them, cultivating a patch of ground and working as day-labourers.

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[1] Iwan Block. The Sexual Life of our Time, p. 134.

[2] The Cochin Tribes and Castes, Vol. I, Chapter I, p.

This altered mode of life brings them in contact with the people of the plains, whose manners and customs they gradually adopt.

Production of fire.—The preparation of food is connected with the production of fire for which the savages exercise their ingenuity in various ways. The Andamanese like the Tasmanian aborigines are ignorant of the art of producing fire, and therefore they always take much care in the methods they adopt to prevent the chances of its extinction. When they temporarily leave their habitations with the object of returning in a few days they not only take one or more of the smouldering logs wrapped up in leaves, but also place a burning log or faggot in some sheltered spot, where owing to the character and condition of the wood it smoulders for several days. The production of fire by friction was the common practice in all Vedic ceremonies in India even from a remote period. Three methods of production of fire prevail among the South Indian tribes. The Panians of Wynad and the hill-men of the Vizagapatam district use the sawing of wood for which they take a piece of dry bamboo split lengthwise and make a notch on the canvex side. A knife edge is then cut on a piece of tamarind wood shaped to fit the notch. A piece of cloth is laid below the notched bamboo across which in the notch tamarind wood is drawn violently till dust drops on the cloth below, till smoke and flame appear in the cloth [1] The flint and steel are used by the hill-tribes of Cochin and Travancore. Quite a different method is used by the Kótas of the Nilgris who use three other forms of the apparatus.[2] The most interesting method of fire-making is by means of fire piston which is extensively used in North Burma, Siam, Malaya peninsula, Malayan archepelago, and in some of the islands of the Phillipines.[3]

Habitation.—Natural shelters, namely, caverns overhanging rocks, holes in the grounds, thick foliage and hollow trunks of trees must have been the abodes of primitive man, and there are some like the Vedas, Hill Pandarams, Kanikkars, Chenchus and others who once have occupied them. It is not possible to say which of these served as a model for the first artifical buildings. The hut is a proto-type of fixed habitation, and the primitive tribes use and construct buildings in varying degrees of simplicity out of the materials available in their neighbourhood. The simplest form of hut is that used by the Gipsy tribes of the Vizagapatam district. A Kadar or a Kani builds a hut in a day or two with his bill-hook, and so long as he is migratory, it is flimsy enough. Sometimes afraid of the wild elephants that roam about the forests during certain months, houses on the branches of trees at certain elevations, are constructed, and they are connected with the ground by means of ladders. The wild tribes that inhabit the Telgu area live in low conical huts rudely constructed of bamboos, and they are thatched with palmyra leaves and grass, leaving a small entrance for the inmates to creep in and out. The abode of the Todas is called a mand (village or hamlet), each of which includes about five buildings, or huts three of which are used as dwellings, one as a dairy and the other as sheltering calfs at night. These huts form a peculiar kind of oval pent up shaped (half barrel) shaped construction usually ten feet high, 18 feet long and 9 feet broad. The entrance is only 32 by 18 inches. The Orans and Mundas of Chota Nagpur have permanent huts having mud walls and tiled roofs. They have become agricultural, and their habits are more or less settled.

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[1] Thurston Castes and Tribes, Vol VI, p. 70-71.

[2] Thurston Castes and Tribes, Vol IV, p. 20-21.

[3] British Museum: Handbook of Ethnographic Collections, p. 14.

Furniture and utensils.—A portion of the hut on one side is raised to a platform on which the members of the family spread the mats of their own making to sleep during night. Sometimes they sleep on cots made of bamboo. Beyond a few mats of their own making, they have no articles of furniture. The domestic utensils consist of a few bamboo vessels of varying thickness whose internodes provide them with a necessary bottom, a few cane baskets for keeping grain, a few earthen vessels purchased from the village markets of the plains below. In some of them are also found some brass vessels and enamelled tumblers. One peculiar feature in the architecture of the lower culture, is the skill in using the materials close at hand and in the means of preserving family and social life. Among the Andamanese, the Nagas, the Lushais, Munda speaking people of Chota Nagpur and among the Dravidian and Central Indian tribes is found the institution of the Bachelor's hall (*Dunkarias*) where the young men of the community live and sleep. Its absence in the case of the small jungle tribes is an indication of the development of their resources, material as well as mental. Nomadism affords no possibility of the development of an institution such as this, and circumstances compel them to nomadism. The earth is the mother of all mankind, out of her they come. Her traits, attributes and characteristics they have so thoroughly inherited and imbibed, that from any doctrinal point of view regarding the origin of species, the earth may be said to have been created for men, and men to have been created out of the earth. By her nurture and tuition they grow up and flourish, and folded in her bosom they sleep the sleep of death.

Weapons and Tools.—Primitive man ransacked his own environment, and got the best out of it which his grade of culture was capable of extracting. His prime necessity was the quest of food, and he was more a gatherer than a hunter, that is, he took from nature what it could offer to him. This necessitated the use of some weapon, the earliest of which was of wood, which he could easily manipulate, and could be obtainable in shapes suitable to his constructive purposes. Even the arrowhead was originally of wood as it is even now among some of the tribes. It was only subsequently that wood was replaced by sharpened stones or iron acquired by barter. It is not difficult to see how wood was fashioned into clubs, axes and digging sticks, and how bones, shells and the like were converted into tools and objects of adornment. The digging stick was the most useful weapon of the women for the gathering of edible and bulbous roots. So also were the club and hammer which could be changed as use required. How the primitive man acquired bow and arrow is not easily imaginable. It must however have been an invention. The boomerang of the Australians is a bent wooden missile pointed at one end. Its curved form has a greater range, and the use of it was learned by the Australians from experience. The Kallans of Madura are said to have used it at one time. The man of nature in passing through the underbrush of the forest must have experienced the hard blows of the branches on his back. He gains a lively impression of the elastic power of bent wood, and this must have led the savage to the construction of a bow. It is said that the bow and arrow may have grown out of a simpler contrivance of spring trap set in the woods by fitting a dart to an elastic branch so fastened back as to let go by a passing animal in whose track it discharges the weapon. It came into use in ages before history. It was a simple matter to render the force permanently available by bending the rod back and bind the ends together with a cord or with strips torn from bamboo itself. From this it is clear that the bow-string thus contrived would communicate the propelling impetus to a lighter wood placed against it. Then there is the arrow which is hurled into the distance by the combined propelling power of the bow and the string. The art of feathering is next introduced. The bow is of several varieties, and that which is used by the South Indian hill tribes is one that is made of bamboo and the ends bound by a string. The arrow does not merely consist of a piece of wood pointed at one end or provided with a stone head or at a subsequent period with an iron head. It is also known that the other end is feathered either with genuine bird feathers or with an imitation of feathers made of palm leaves. The addition of the feathers is supposed to ensure accurate flight of the arrow. The flight of the bird must have suggested the movement of the arrow. To the primitive mind the image of a thing is the same as the thing itself, and the qualities of the bird are transferred by force of magic to the arrow.[1] The magical motive is in harmony with the mechanical effect. Many are the varieties of the arrowheads planned and made by the primitive tribes. Equally useful and important to the savage in hunting is the spear which is a long stick one end of which is pointed. and is at a later stage provided with a pointed head of stone or iron which also are of many varieties. The subsequent advance in the development of weapons and implements is one of stone of which also there are many varieties. The Andamanese were until recently using Cyrena shells and quartz flakes as cutting instruments. Even during the days of Dalton, the Juangs and other hill tribes had no knowledge of metals. In many parts of South India stone implements are found, and they are regarded as thunderbolts. It is said that copper implements have been found in the Central Provinces, the Gangetic Valley, and Burma. The modern Hill Tribes are aware of the superiority of iron, and consequently the forms of stone implements were all imitated in copper, bronze and iron, and they were very much improved to suit their tastes. Nevertheless few are the weapons and implements found among the South Indian hill tribes. The bill hook and the ordinary axe are the most important of them, and wonderful are the uses they make of it in their daily lives.

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[1] Wundt: Elements of Folk Psychology, p 26.

Geographical Distribution —The tribes that live on the hills of South India are the survivals of the autochthonous race that once occupied the whole of the peninsula. They are now found in isolated groups scattered over the hilly regions. The Khonds who live on the hills of Ganjam and Orissa seem to have been pushed up to their present abodes. They have now become a dominant tribe with artisans and menials to work under them. In addition to their being keen hunters, they are agriculturists of a rude type. The Poraja who belong to the same stock speak a mixture of Khond and Oriya, and occupy a position between Gond and Kond. Next come the Gadabas, who are said to be a branch of the Poroja and their subdivisions confirm this view. The tribe has no tradition of migration and live mostly by cultivation. Allied to the Khonds are the Jatapus who are said to have become brahmanised. Those residing near the hills speak Kand. There remain the Savara tribes of whom a large majority is found in the Ganjam and the Orissa hills, and in the Central Provinces. At one time they possessed a considerable dominion south of the Gangetic Valley. It is curious to note that their communities in small numbers are found in Bundelkand in the extreme north of the Central Provinces with no tradition of migration nor any of their former supremacy. The wilder Savaras have no exogamic divisions, but those who left the hills have established themselves on totemic and exogamic lines. They have the functional divisions. Another range of hills occupied by the hill tribes in small groups is the Nilgris. They are five in number occupying the hills on various elevations with different occupations. The Todas are pastoral; the Kurumbas and the Badugas are agricultural. The Kotas are blacksmiths The Irulans who live in the broken country are apparently of the same stock as the Chenchus. In the ranges south of the Nilgris are several small wild tribes most of whom live in their wild state more or less. The Kanikkars of Travancore are said to be the descendants of a race who once held dominion over the plains below, but driven to the hills by invaders from the north. They cultivate the soil by the use of wood ash as manure. The Mala Arayans or the Arayans of the hills are becoming settled and have considerable areas of cultivated land. The Kadars and Malcers belong to the hills of the Cochin State, and so also are the Paniyans and Kurichans of the Wynad and the Nilambur hills. In the low ranges of the Eastern Ghats on the Coromandel coast are found the Yanadis and the Chenchus who are related to each other. They also belong to the autochthonous race. Chenchu is the title of the subdivision of the Gadaba tribe. and the same name is given to the Irulans of the uplands in Mysore.

Language.—Language is a function of social life, and since man is a "social animal" from the beginning, he first spoke a language of an articulate kind. Philology teaches us that the most polished language can be traced back to primitive dialects, and that the written word was at first a picture, then a hieroglyphic, and next a group of phonetic signs which has thus an ancestry less remote. As it is with words, so it is with subjects. When man cannot find words, to express his thoughts, he uses gestures to make up the absence of vocabulary. Among the Australians and others gestures serve as a sort of secret language. It is only the natural development of those expressive movements of human beings that also occur where the intention of communicating, is obviously absent. The gesture language is well expressed by the actors of the Malabar dramas.

"There is," says Hodson, "a great deal of social history and social effort in every word, since there must be accord between the speaker and the hearer as to the significance and import of the sounds."[1] Language is bound up with thought. From the phenomena of language inferences may be drawn concerning the general characteristics of thought. The original language of the primitive people no longer exists. The Veddas of Ceylon speak the language of Sinhalese and the Tamils. The hill-men of Malabar, Cochin and Travancore speak mutilated Malayalam, while those in the Tamil and the Telugu speaking regions use vulgar Tamil and Telugu. Linguistic investigations defeat all efforts to discover the original language of the primitive man. Here the most well-known principle of the struggle for existence is to the field of mental phenomena. The stronger race crowded out the most important mental creation of the weaker language, and the weaker language succumbs to the language more highly developed. Primitive tribes isolate themselves with great anxiety. The intercourse between the older inhabitants and the newer people led to a competition of languages in which the powerless one succumbed. Nevertheless the primitive language may have exercised a reciprocal influence upon the more advanced.

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[1] Hodson: Primitive Culture of India p. 46.

Sex and Marriage:—Sex plays an important part in the history of primitive culture. It affects the social structure from which arises the union of the sexes or marriage. The term marriage has been variously defined by sociologists, and in a rudimentary form existed even from a remote period. The earliest marital connections are ascribed to promiscuity, then to group marriage both of which have not attained the rank of scientific certainty. Then there are other forms of marriage, the *Paisacha*, *Rakshasa* (marriage by capture), *Asura* (marriage by purchase), and marriage by exchange, the survivals of which are to be found in the marriage ceremonies of the primitive tribes. Traces of the same can also be found in the marriage ceremonies of the lower and the higher castes of South India. In this connection it may be observed that according to the *Hindu Dharma Sastras* there are the eight forms of marriage of which four are said to be "approved" and they are devoid of any bride-price.

Marriage leads to the permanent living together of man and woman. Marriage ceremonies neutralize the dangers attaching to the union of both sexes. The essence of marriage lies in the joining of hands of the bridal pair. Wedding takes place some times in the evening with some tribes and castes, and with others during night. It is a custom natural enough to avoid the dangers arising from the potency of evil eye, female shyness and timidity. Another important feature is that in which the personal adornment plays not infrequently an important part, its primary motive being to attract the opposite sex. It is also an aid to sexual selection. Wedding garments are costly and are intensified by personality. It is an occasion of expansion and augmentation and it is specially adapted to the social expression of love. Among the high castes in South India, as among other civilized communities, the bridal pair assumes super-humanity, and are treated as Royal persons. Magnificence is the characteristic of wedding garments throughout the world, and this is particularly to be noticed in South India. White colour is the expression of virginity, and red is often an adaptation to circumstances.

Other forms of marital connections such as polygamy, polyandry and levirate are based mostly on economic grounds, and are fast disappearing in South India.

Family.—It is said that family arose out of chaos; but the data on which this is based do not appear to be satisfactory. It must have arisen from a kind of marital relation, so that the family must have consisted of the father, mother and child in a rudimentary form. The child was so close to the mother, that the descent came to be reckoned with her. This was called mother-right, and from this arose the father right. The former is found in all parts of the world, where social advance is at a certain level, and the evidence warrants the assumption that every group that advances to a culture state passes through this stage. With a few exceptions the descent was first reckoned in the female line, and traces of it are to be found in some parts of Africa, China, and Japan, as also in India among the Khasias and other tribes of Assam, as well as among the Nairs and the allied castes of Malabar, Cochin and Travancore. The father-right exists in a typical patriarchal family. Whichever way the descent was reckoned the members of the family lived together until they grew to such an extent as to necessitate a division for convenience and comfort. A group of such families is known to ethnologists as gens or clan; and a number of such clans related to one another formed a tribe. Here the mother-right invariably prevailed, and the name of each clan was mostly derived from some animal or plant which constituted its totem that was regarded as its ancestor and supposed to be watching over the welfare of its kindred. The clan and the internal structure of each tribe or caste in South India requires thorough investigation. The totemic system above referred to is so closely connected with primitive marriage and kinship that they became marks of prohibited degrees. The members cannot intermarry, and the practice of marrying out is known as exogamy, while that of marrying within its limits is known as endogamy.

Property.—Closely connected with marriage and family is the property, the three kinds of which are personal, family, and tribal. It is well illustrated in the following proverb of Deniker: "I have made a flint implement with my own hands, it is mine; with the assistance of my wife and children I have built a hut, it belongs to my family; I have hunted with the people of my tribe, the beasts slain belong to us in common."[1] Where agriculture is practised, the lands belong to the community as a whole. Gradually it is divided among different families, and is very often redistributed at various intervals. This in due course leads to the evolution of private property as a result of effective occupation.

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[1] Deniker: The Races of Man, p. 245.

Occupation and Trade—Trade originally began with barter or exchange of articles, and this gave rise to currency which is different in different parts of the world. Among them may be mentioned shells, bright feathers, axes, fish-hooks, blocks of salt, cowries, and hundred other things that have become the indispensable media of exchange. Trade, itnermarriages, and war have led to the formation of alliances. The way was thus prepared for the state.

The occupation of jungle tribes consist in hunting, fishing and pasturing the last of which required the domestication of animals. Agriculture and industrial arts came in only later.

In primitive technology, again, the rude appliances of mechanics, agriculture and architecture in their infancy, primitive warfare and navigation, early ceramic and textile arts, the origin of drawing and sculpture, rudimentary contrivances for economic exchange, all these have more than a substantial interest for our own age. A full comprehension of an art or an industry is possible only by having an idea of its genesis and growth in its earlier stages. A knowledge of this kind broadens the view, and deepens the sense of continuity in change.

Group Solidarity—It is a characteristic of primitive society that a member of a tribe considers that he forms part and parcel of the tribe; and never regards himself as separate unit. He and the members of the community have a headman who is the representative of the outside world. It has been said that a tribal group is a social unit with vague unwritten laws the violation of which brings on serious punishment. Social solidarity is maintained by the idea of vicariousness which makes it the business of every man to see that his neighbour respects the laws.

As custom is the mother of all laws, whether written or unwritten, customary or positive, it may be seen that the law of primitive communities, is to a large extent based on custom arising from the principle of give and take, necessary to all forms of social life. But customary law is often modified by ceremonial law which takes its origin from religious beliefs. To begin with there were at first no regular judges except the public opinion of the clan which used to award simple and sometimes severe punishments, like exile or death. In the evolution of criminal law, 'vendetta' or blood feud or blood revenge is an important factor. War and trade constitute the only external relations of the tribe. The savage when left to himself is harmless; but when he feels disturbed or otherwise injured he acts on the defensive His efforts are for the protection of his person by terrifying the enemy. In course of time the tribes submit to the authority of the headman and an assembly of elders, who manage the affairs affecting the welfare of the community. Fine and excommunications were the usual punishments. Survivals of these institutions exist, though altered to some extent in character, in every tribe and caste.

Religion.—Man in his relation to the supernatural appeals to the ceremonial law which merges into the customary law. At a certain stage they become so fused that they lead to the supernatural. Here taboo plays an important part. Danger is the root idea of pollution, and the savage cannot distinguish the one from the other. To guard against these dangers is the object of taboos which may be defined as prohibitions enforced by magical or religious sanctions. If these prohibitions are disregarded, disaster is believed to follow.

Another interesting feature about the primitive man is that the savage is vaguely conscious of his own will-power which he attributes to the objects around him. Further out of the notions of life and breath, shadows and reflections in the water and the visions seen in dreams, he builds up his theory of soul which is the vital essence of man. The soul is considered to be a separable personality of the living man or other beings, while a spirit is a soul-like being that is never associated with a human or a spiritual body. The ghost also means more or less the same thing after death. In fact all the three are of the same type, and are visible, invisible, and can assume any form they like. This leads to the Tylor's theory of animism, and the prevalence of it in one form or another is found all over the world. The gods of savages are developed out of two classes of spirits, namely, the ancestral spirits and the spirits of nature. They are a numerous but not an organized body. As social organization develops, tribes amalgamate, and differences of rank appear. The supernatural hierarchy is remodelled after that of the earth. There arises thus a heavenly hierarchy of gods out of the confused multitude of spirits. Polytheism or the worship of a company of gods is thus developed, and this leads on to the worship of a single superior deity. It is possible that the ancestor worship may lead to the belief in a single ancestor, and that the worship of the spirits of nature may suggest that the world, taken as a whole, is also a divinity. It is also held that the worship of a single superior deity is far earlier than any other. It must also be said in this connection, that each man has a guardian spirit to watch over his welfare. Primitive mind is always occupied with the problem of maintaining an intimate relationship with spirits that are propitiated by ceremonies, prayers and offerings. The dances of the savage are religious in this sense and so are some of his games.

It was at this stage that music was developed as an accompaniment to the ceremonial dance. In the combination of the song and dance, of the spoken expressions of social fancy, emotions, and the acted representations of the deeds told of in speech, we have a height of aesthetic attainment to which the lower culture often attains. Sir W. Ridgeway avers that wide induction leads irresistibly to the conclusion that tragedy and serious drama have their beliefs in the world wide belief in the continued existence of the soul after the death of the body. Throughout the lower culture are found funeral dances for the honoured dead, and agricultural rites to secure prosperity of the living, and to keep up a constant relation with that of the departed and their well-being in their dual state. All kinds of ceremonial and funeral dances are the pastimes with the hill tribes, and they survive even now among the lower and the higher castes in South India.

It is interesting to note, in this connection, the relation between magic and religion. Religion, says Robertson Smith, is for the good of the community, while magic represents its relation for the individual. How far the functions of the witch doctor agree with those of the priest, it is not possible to say. They are usually treated together, because they are sometimes closely intertwined. Religion is orthodox, social, or communal, while magic is individualistic, anti-socialistic, and heterdox. Religions refer to a variety of subjects which include ritual and sacrifice, spell and prayer, omens and divination, while magic confines itself to witchcraft and the potency of evil eye. Such in brief is the outline of the subject of Primitive Culture.

Conclusion.—Practical value of the Study of Primitive Culture.—It may be asked by some sceptically minded people, what is the practical value of the study of the subject? The foregoing pages may indicate an answer. "The story of the primitive man has a direct relation upon the intellectual, industrial, and social state of the cultured peoples. It explains how our forefathers passed from a state of savagery to civilization. It affords a reason for the moral and material survivals which confront the investigator in the most varied fields of historical research. Every practice and custom now in vogue among the advanced society of men, has its history short or long, and can in a surprising manner be traced back to primeval times." Again, we learn from philology that the most polished languages claim their origin from primitive and uncouth dialects, that the written word at first a picture, then a hieroglyph, and next a group of phonetic signs, has an ancestry entirely remote. As it is with words, so it is with subjects, which they express. Then again, many popular beliefs can be recognized in the myths and legends of the rudest tribes. A number of curious customs and superstitions still linger on in town and country, and betray on closer scrutiny, their origins from a far more ancient stage of culture. In law survivals from ancient practices are still persistent. Again, in the provinces of morals, varying degrees of emphasis laid on certain aspects of virtue and vice are fully understood only on a proper comprehension of primitive ethics. The comparative study of primitive religion arising therefrom is equally interesting and instructive. There is, in fact, no branch ot socialogical or historical research, which has not profited by an ethnographical method of reviewing facts derived from all stages of human culture.

Pygmy Implements from the Lower Godavari.—*By* L. A. Camiad.

Introduction.

Pygmy implements have been discovered in many parts of Asia, Europe and Africa, but up-to date little is known of their origin or of their date.

The implements recorded hitherto are all flakes and the flakes are of only 4 or 5 rather obscure types.

The backwardness of knowledge concerning the origin and use of pygmies is due to the scantiness of pygmy camps in Europe and the paucity of types found in those camps.

India is rich in pygmy camps but they have not been closely studied.

Part I.

Types of the Godavari pygmies.

In the valley of the Godavari over 100 pygmy camps were explored. They disclosed a complete range of well-made implements, all of dwarf size, including adzes axes, gouges, a large variety of specialized cutting, boring and chiselling implements, besides hammer-stones, anvils and grinders.

Part II.

Age of the Godavari pygmies.

The range of implements found show that the pygmies are not a mere side industry of some stage of culture but a complete culturial stage.

In shape, size and technique these implements have affinities with the last palaeolithic period and seem to be early neolithic.

This is an opinion which has already been expressed in regard to pygmies found in France and Belgium. The Godavari pygmies seem to corroborate this view very fully.

A later neolithic age seems however to be suggested by the situation of the pygmy camps, as well as by the position of the implements in the camps and by the occasional occurrence of pottery and of ground implements.

A still later date is suggested by the occurrence of pygmies in intimate association with urn burials.

And, pygmies seem to have been associated even with proto-historic burials.

It is possible that the pygmy culture in the Godavari valley, if not in India generally, had a long duration and pygmies may have seen the implements of the now submerged negritos of India. The pygmies of Southern India bear a very close resemblance to those of South Africa.

On the Cult of the Jujube Tree.—*By* S. C. Mitra.

A godling named Itokumara or Ishtokumara, who is believed to preside over matrimony, is worshipped by unmarried girls in the district of Pabna in Eastern Bengal and in some parts of the district of Nadiya in Central Bengal. The maidens worship him for obtaining the boon that they may get married soon. His worship is strictly prohibited to married girls. This godling is believed to be immanent in the jujube-tree (Zizyphus jujuba). For this reason, no anthropomorphic image is made of this godling who is symbolized by a branch of this tree. This branch of the jujube-tree is worshipped by the unmarried girls with offerings of wild flowers and to the accompaniment of the recital of mantras or charm-formulae of which the main constituent elements are (*a*) entreaty, and (*b*) the description of the imaginary occurrence of certain events in the godling's own life which is believed to result in the speedy happenings of similar events in the worshippers' lives. This "Cult of the Jujube-tree" is a striking illustration of the great doctrine of Animism.

On a Meithei Apologue and its Bengali Variant.—*By* S. C. MITRA.

There is current among the Meitheis of the Valley of Manipur an apologue or "a story with a conscious purpose and a moral which illustrates the truth of the saying that "Cunning is outwitted by cunning." The Bengalis appear to have borrowed this apologue from the Meitheis and, after giving it a local colouring and fitting it into a Bengali framework, assimilated it as their own. The following story-radical, which fits into the Meithei and Bengali versions, has been framed :—

(1) A person dies leaving a milk-yielding beast, a fruit-bearing tree and a textile fabric.

(2) One of his two sons, who is more cunning than the other, defrauds the other by giving the latter the unproductive parts of the beast and the tree and by compelling the latter to keep the textile fabric during the day-time.

(3) The simpleton brother, on the advice of others, outwits his cunning brother by trickery.

(4) Thereafter each takes his half-share of the products of the beast and the tree, and uses the textile fabric alternatively or divides the sale proceeds thereof equally.

Note on a Tamil Cumulative Folktale of the Old Dame Lousy Type.—*By* S. C. MITRA.

In view of the discovery of this new Tamil variant, the story-radical, which the author has framed for the Cumulative Folktales of the "Old Dame Lousy Type," has been modified as follows :—

(1) The heroine of the tale, whose name is Dame Lousy, or who is the queen of the rats, dies.

(2) Thereupon a bird, in order to give vent to his grief at her death, fasts for several days. Or the rat-queen's husband sits sorrow stricken under a tree.

(3) Thereafter some calamity or distressing incident happens to the other actors in the tale, or the other actors throw away or break something in order to give vent to their grief.

(4) In one case, some of the latter actors are extricated out of their distressful situations.

Note on a Recent Instance of the Folk-belief that the Water Goddess Demands Human Sacrifices.—*By* S. C. MITRA.

There is a belief current among the commoner folk of Southern Bengal that the goddess presiding over a tank demands human sacrifices. An instance of this belief, which has recently cropped up in the village of South Barasat in the district of 24 Parganas in Southern Bengal, has been described in this paper.

Crab folklore.—*By* S. T. MOSES.

The crab in astronomy, a constellation and a sign in the Zodiac—Western mythological account of its presence there—The sign so called as the Sun makes a crab-like sidelong motion after reaching the Cancer—Aesop's fable regarding crab's gait—Kadaga Sankaranthi or Summer solstice.

The crab, a model of conjugal faithfulness in astrology—Rama's horoscope.

Some stories of crabs—Cuvier and the lexicographer—St. Xavier and the cross crab and the rosary crab—The story of the crab and stork in Panchatantra.

The crab and its edibility—The Kondras of Ganjam and crabs—The Pallars and their crab flag—Sunnis and crabs—The ball crabs and famine on the 'Fishery Coast'—'Red Water' and the miraculous appearance of shoals of crabs at Cannanore in 1507—The nursery rhyme regarding uses of eating crabs, chanted in Coorg—Crab's tasty nature from a Tamil riddle and a Tamil proverb.

Crabs in medicine—Some popular beliefs. The dhoby crab and earache. Palnandu and pneumonia—Peacrabs and nervous debility. Land crabs and baldness of the head.

Poisonous crabs—Some innocuous ones judged poisonous by appearances. Some reckoned poisonous only during October and November in the West Coast—Fra Bartolomeo's instance. A popular belief of scorpions being transformed crabs. Crabs hence denied admission into houses—auspicious if seen in land where foundation of a house just beginning to be laid.

The crab in some South Indian proverbs.

Notes on a type of sedentary game prevalent in many parts of India.—*By* HEM CH. DAS-GUPTA.

In this paper the author has described a type of sedentary games prevalent in many parts of India and usually played on a plank in which a number of shallow holes has been scooped out and the holes are filled up with small pieces of stones, cowries, tamarind seeds, etc. The game is known as *Máwkárkátiyá* (among the Khasis), *Vain lung thlan* (among the Lushais), *Kánji guti* (among the Oriyas), *Ománguntá peetá* (among the Telugu-speaking people) and *Pálánguli* (among the Tamil-speaking people).

Indian concepts about Man's place in Nature.—*By* P. MITRA.

Ideas in Sanskrit Literature about Man being the top of an evolutionary series. Physical and Biological Evolution in Indian Literature. Psychological and Sociological Evolution in Indian tradition.

Different elements and currents in the Socio-Religious life of a modern Hindu.

A primitive stratum—exogamic and partly totemistic. A later developed phase—mother-goddess worshipping and matriarchic. A philosophical Naturism based on the Aryo-Vedic Literature. An influence of amalgamated Hinduism and Buddhism of the 5th century A.D. An influence of later developed religious movements of the mediæval period of *rapprochement* between Hinduism and Muhummadanism typified by Kavir, Nanak, Chaitanya, etc. An influence of the attempts at evolved ententes between Hinduism, Muhummadanism and Christianity since British days. e.g. typified by Raja Rammohan Ray, Kesav Chandra Sen, Satsanga movement in U.P. of Sivdayal, Saligram and Brahmasankar, Ram Krishna-Vivekananda movement and the Neo-Satsang movement in Bengal.

Teruvan: a little known non-indigenous Caste of Malabar.—*By* P. V. MAYURANATHAN.

In Edgar Thurston's Castes and Tribes of South India the Teruvan is treated of as being identical with the Chaliyan. But for the fact that both are a class professional weavers, the writer sees nothing in common between them. A brief account of the caste showing the important points in which it differs from the Chaliyan is given.

Marriage Customs among the Muduvans of Travancore.—*By* L. A. KRISHNA IYER.

The Muduvans of Travancore are an interesting hill-tribe found on the Cardamum Hills bordering the district of Madura and in the Neriamangalam Valley.

Marriage generally takes place after puberty, and is between cross-cousins, *i.e.*, between the children of brother and sister. The presentative of a cerub made of bamboo or reed forms an essential part of the marriage ceremony. The system of 'marriage by capture' is also in vogue among the Muduvans. Re-marriage of widows is permitted.

The Muduvans afford an example of 'happiness without culture,' and show signs of progressiveness with the march of civilisation.

Anthropology at the Crossroads.—*By* F. J. RICHARDS.

I. *The Problem.*—Scientific Progress—Manifold origins of Anthropology—Its slow progress—Preliminary survey completed—Need for intensive study—Need for co-ordination—Practical utility of Anthropology—Outsiders to be convinced—The fault is with Anthropologists—Urgency of the Problem.

II. *Solution.*—An Ethnological Bureau for India working in co-operation with the Royal Anthropological Institute of Great Britain—Secretaries and correspondents—Relations with Local Societies—Publications—Need for Economy and increase in sale—Possible alternatives—Propaganda.

III. *Scheme of Studies.*

Anthropological Geography.—*By* F. J. RICHARDS.

I. The Value of Geographical Analysis.
II. Geographical Factors.
III. Areas and Avenues.
IV. Geography of South India.
V. Application.

I. The value of Geographical Analysis.—Problems of Distribution and Convergence—Cultural Drift—Stratification—Influence of Environment—Laxity of present methods—The Discipline of Geography. II. Geographical factors.—*A.* Physical: (*a*) Configuration, (*b*) Climate, (*c*) Economic Products, (*d*) Flora and Fauna. *B.* Human Phenomena: (*a*) Density of population, (*b*) Races, (*c*) Languages, (*d*) Religion, (*e*) Political Divisions. III. Areas and Avenues.—*A.* Basis for classification and definition—Frontiers. *B.* Types of area: (*a*) Centripetal, (*b*) Centrifugal, (*c*) Transitional, (*d*) Marginal, (*e*) Terminal, (*f*) Isolated. *C.* Routes. IV. Geography of South India.—*A.* Physical: (1) Ghats, (2) Plateau, (3) Coastal plains, (4) River basins. *B.* Human: (1) Areas of density, (2) Areas of sparseness; (*a*) Transitional, (*b*) Isolated; (3) Marginal and Terminal areas. *C.* Routes. V. Application.—(1) History and Prehistory, (2) Race, (3) Language, (4) Economy, (5) Religion, (6) Social.

Suggestions for the Classification of Indian Pottery.—*By* F. J. RICHARDS.

I. Need for a uniform Terminology—Local and Linguistic differences—Pottery as an index of date.

II. Basis of classification: (1) Base—(2) Body Forms (Profile)—(*a*) Bowl types—(*b*) Jar types—(3) collar, neck—(4) mouth, lip, rim—(5) Stands and Pedestals—Legged Jars—(6) Handles, Spouts, Lids—(7) Decoration—(8) Fabric.

III. Application: Establishment of sequences—Cautions—Perumber—Adichanallur—Nilgiris.

The Baby Language among the Parsees.—*By* Dr. JIVANJI JAMSHEDJI MODI.

Babies among all people seem to have two kinds of languages. The one is the kind of mute language which they utter both in their smiles and cries. It is the language referred to in the New Testament as "out of the mouth of babes and sucklings thou hast perfected praise" (Math. xxi). The second is that which babies speak when they begin to prate. They learn it from their mother's lap. The author then gives a number of words uttered by Parsee babies in their first attempts.

The Antiquity of the Custom of Suttee.—*By* Dr. JIVANJI JAMSHEDJI MODI.

Dr. J. Eggeling in his article on "Brahmanism on Suttee" in the Encyclopædia Britannica says that the custom "seems to have sprung up originally as a local habit among the Kshatriyas, and on becoming more and more prevalent to have at length received Brahmanical sanction." The object of the paper is to show that the custom (*a*) was not confined to India and (*b*) was very ancient.

The fact that Classical writers like Diodorus Seculus and Strabo refer to it shows that the custom was prevalent long before the Christian era. Diodorus who travelled in Asia and lived in the first century B.C. refers to a case of suttee in the camp of Eumenses, the Private Secretary of Philip of Macedon and his son Alexander. Strabo (B.C. 54–A.C. 24) on the authority of Aitistobulus who accompanied Alexander the Great to India refers to wives burning themselves voluntarily with their deceased husbands.

Again the custom was not confined to India. It also prevailed among other people of the old Indo-Germanic stock. Herodotus refers to the custom among the ancient Thracians. Tacitus refers to the prevalence of the custom among the Winedi, an old German tribe. Masoudi, an Arab writer, describes the custom as prevalent in a Caucassus tribe. Yule refers to some countries other than India where the custom was prevalent.

The motive of the custom is attributed by some scholars to a particular belief about future life among primitive people to the effect that some material wants were felt by the dead in the other world, and so with other things women had to be sacrificed to supply such wants. That may be so elsewhere, but in India the motive seems to be suggested by the high ideal of love and affection among some wives. The Parsee view of performing the funeral ceremonies in double suggests a high ideal of wifehood.

A somewhat similar custom seems to have prevailed even in old England. Some recent excavations in England point to that fact and confirm what is said above; Tacitus said that "the pagan Saxon wives slew themselves when their husbands died."

The theory of migration from India.—*By* J. H. HUTTON.

The theory of migration from India would be expected to account for a certain similarity between the cultured pre-Hindu tribes and of the Pacific Islanders, but the similarity is closer in the case of the Naga tribes than has been hitherto realized. This is exemplified by the similarity in the use of stone and in the practices and beliefs connected with death. There are indications to show that these cultures reached Assam from the south, and as the result of some trans-marine migration, the centre of disposal was perhaps Indonesia rather than India.

The Baigas of the Central Provinces.—*By* HIRALAL.

A tribe without distinctive language—Some of its characteristics—Probable connection with the Vadugos of the South.

The Kurumbas of Madras Presidency.—*By* T. J. KUMARASWAMI.

(1) Their population according to 1921 Census—(2) Their greatness during the days of the Pallavas—(3) Their administration and the power of their assemblies—4. Their caims, barrows, asarams, kistvaens cromlechs—(4) Their physical characteristics—(5) Their houses—(6) The various divsions among them—(7) Their religion—(8) Their customs and manners—(9) Their occupation.

The Future of Ethnographic Research in India.—*By* C. H. RAO.

Present state of research work in Ethnography—Work accomplished so far—What remains to be done in regard to Anthropometry—In regard to origin of Caste—Further study of selected Castes and tribes—Other main heads of research—Extent of Mother Right in India—Study of Family and kinship systems on the classificatory and genealogical systems—Study of the Evolution of Handicrafts—The study of place-Names and proper names—Linguistics from the Somatological point of view—Organization of a genuine pre-historic survey of India for the study of fossil Man and primitive Man in India—Founding of a Bureau of Anthropology in India under the ægis of the Ethnographic section of the Congress—Details about the proposed Bureau—Advantages to be derived from it.

The Bhils of Jaisamand Lake in Rajputana.—*By* SARAT CHANDRA ROY.

The Bhils of Jaisamand Lake—Their habitat—Occupation and mode of life—Kinship and social organisation—Religion and other customs.

An American Tribe and its Buffalo, and an Asiatic Tribe and its Fish.—*By* DR. JIVANJI JAMSHEDJI MODI.

The author compares the eating, dressing and living habits of some American tribes like the Algonquian on the Mississippi, referred to by Mr. Bushnell in the Bulletin No. 77 of the Smithsonian Institution Bureau of American Ethnology, with the Asiatic tribe of the Ichthiophogy on the coast of Mekran, referred to by classical writers like Arrian, Strabo and Curtius Rufus. These tribes illustrate the fact that the physical and other conditions of people depend, to some extent, upon their environments which affect the questions of their Heritage of Food, Dress and Dwellings,—questions which are influenced by what is called the "Bread and Butter Theory" referred to by Mr. E. Huntington in his "Pulse of Asia." The American tribes lived on the buffalo, dwelt in dwellings made of the hides of the buffalo and dressed themselves in skins of the buffalo. Similarly the Asiatic tribe lived on fish, dwelt in houses made of the bones and scales of fish and dressed themselves in the skin of the fish. Fish-bread was their staple food and grain which grew there very little was used merely as a little relish with the fish-bread. Water also, being rare, was drunk every five days at some distant watering places where families went with songs and rejoicings and drank "throwing themselves on their faces as beasts until their stomachs were distended like drums." Firdousi and Diodorus Seculus refer to the enormous size of the fish on the Mekran coast which surprised the Greek soldiers of Alexander the Great as it surprised the Persian soldiers of King Kaikhosru of Persia.

Exorcism of Spirit in India and Exorcism of Physical Impurity in Persia.—*By* Dr. Jivanji Jamshedji Modi.

Rai Bahadur Sarat Chandra Roy has in the March 1923 number of the "Journal of the Bihar and Orissa Research Society" given a paper entitled "Exorcism in Chota Nagpur." In one of the songs of the Mantra recited at the time of exorcism we find various parts of the body, from head downwards up to the toe of the foot, mentioned in succession in the regular order of which the spirit possessed by the patient passes from the head down to the ground. The object of this paper is to describe a part of the process of removing or exorcising the Daruj-i Nasush, the Demon of Impurity, from a person infected by coming into contact with a dead body, wherein the various parts of the body are similarly spoken of as those down which the Nasu passes from the head downward.

The following table gives a glimpse of the order of exorcism in the Indian and Iranian processes :—

Indian.	*Iranian.*
From Hair to the	
Head	Head
Forehead	Forehead
Eyes	The hind parts of the head
Nose	Cheeks
Mouth	Right ear
Teeth	Left ear
Tongue	Right shoulder
Lips	Left shoulder
Neck	Right arm-pit
Shoulders	Left arm-pit
Chest	Upper part of the breast or chest
Waist	Back
Thigh	Right breast
Leg	Right rib
Ankles	Left rib
Heels	Right buttock
Soles of the feet	Left buttock
Toes of the foot	Abdomen
Toe nails down to the earth	Right thigh
	Left thigh
	Right knee
	Left knee
	Right calf of the leg
	Left calf of the leg
	Right ankle of the foot
	Left ankle of the foot
	Right instep
	Left instep

Indian.	*Iranian*
	The sole of the right foot
	The sole of the left foot
	Toe of the right foot
	Toe of the left foot.

Most of the parts of the body in both are common. The Vendidad purifier of Iran leaves aside the arms and makes the physical impurity pass, as it were, in one line from up to down below. But the Indian spirit-doctor attends to these side portions also. Again in the Vendidad the right and the left parts of the body are treated separately. The Vendidad in the end lets the impurity pass to the North which was, according to the Iranians, the seat of all evils. The Chota Nagpuris let the spirit pass in the end to the Earth which is "its proper habitation." Among both, the patients return to the normal state of health after the treatment.

The Root-idea at the Bottom of Nudity-Spells.—*By* DR. JIVANJI JAMSHEDJI MODI.

Mr. Sarat Chandra Mitra in his recent paper entitled "A Recent case of the Use of Nudity-spell for rain-making in Northern Bengal" and Mr. Crooke in his "Popular Religion and Folklore of Northern India" refer to customs wherein women, at times of scarcity of rain strip themselves naked and dance before the rain-god. Both the learned authors say the root-idea at the bottom of the custom seems to be to frighten the god to force him to pour down rain. Dr. Modi suggests the following ideas as well: (*a*) An appeal to the rain-god, as suggested by Mr Conway on the ground of poverty and inability. (*b*) Temptation to allure the rain-god who is supposed to possess passions and desires like women. (*c*) An expression of humility like that expressed by a candidate for invitation in masonry, who appears before the master, as it were, in a kind of half nudity, having parted with his upper garments and his money, even all metallic things like his keys, spectacles which may count for money however little. (*d*) Shaming the rain-god and thus forcing him to pour forth rain. This view is illustrated by the story of Cyrus the Great of Persia related by some classical writers like Strabo wherein the Persian women went before their male soldiers who were running away from the battle with the Assyrian soldiers of Astygis towards their capital city of Pasargadae (modern Murghab). The women exposed their sexual parts and pointing towards them put the flying soldiers to shame and forced them to go back to the battle-field and fight for their country. The result was a victory for the Persians. All future kings whenever they went to the city always gave a silver coin to every woman there to commemorate the above event. (*e*) The idea of self-surrender or sacrifice which lies at the bottom of many modern practices of salutation. Here the women offered to surrender or sacrifice what was most dear to them, viz. their high sentiments of decency. The case of the women of ancient Babylon illustrates this. According to Herodotus every native woman of Babylon was obliged, once in her life, to sit in the temple of Venus and have sexual intercourse with any stranger who gave her a silver coin which she could not reject however small it may be. "When she has had intercourse and has absolved herself from her obligation to the goddess she returns home and after that time however great a sum you may give her you will not gain possession of her." In this case, the women offer to their god what is most dear to them, viz. their chastity.

Many a custom passes from the Church to the State or to Society. Occasionally we hear that in modern Parliamentary elections, a lady, on behalf of her candidate, to gain the favour of the voter, who then is, as it were, her temporary god, gives to the voter a kiss, thus sacrificing her modesty. During his visit of Japan in 1922, the author of the paper said, he saw in the temple of Hegoshi Hingwa large heaps of the hair of 4000 women of Japan which they had offered to the temple to form ropes to help the work of reconstruction of the temple. Here the Japanese women offered what was most dear to them, which gave them beauty, their hair. The occasional instances we hear of women giving the right of the first night to some high priests who pose as the representatives of gods in this world, illustrate the above views.

Joint Meeting of the Sections of Mathematics and Physics, Chemistry and Agriculture.

DISCUSSION.

On the Rôle of Surface-forces in Physics and Chemistry

1. Physical Theories of Surface Energy.—*By* C. V. RAMAN.
2. Rôle of Surface-forces in Electrolysis.—*By* J. C. GHOSH.
3. Rôle of Surface in Colloids *By*.—J. N. MUKERJEE.
4. Rôle of Surface in Catalysis.—*By* N. R. DHAR.
5. Surface in Soil Physics and Soil Chemistry.—*By* B. H. WILSDON.

Physical Theories of Surface Energy.—*By* C. V. RAMAN.

Owing to absence from India Prof. Raman has been unable to arrange for inclusion of his observations in the Proceedings.

The Rôle of Surface Forces in Electrolysis.—*By* PROF. J. C. GHOSH.

The problem of finding out the electromotive force at the boundary of a metal against its ions in solution is yet to be solved. There are three methods for determining this magnitude.

(1) Capillary electrometer method, (2) drop electrode method and (3) the method of Billitzer based on the observation of motion of charged particles in a liquid. The first two methods give results which agree among themselves but differ widely from the value of E.M.F. obtained from the third method. Freundlich and Rona have recently suggested that at the limiting surface of two phases, two kinds of potential differences exist. The electro-kinetic double layer lies wholly in the liquid, and the electrokinetic potential represents that part which falls in the displaceable liquid layer. The thermodynamic or Nernst potential, on the other hand, is the whole potential difference existing at the surface of separation. The capacity of a mercury surface against solution as determined by the capillary electrometer method gives 26 microfarad per sq. cm., while other methods give values of capacity which are much less. This gives prominence to the view that the nature of a surface layer is a composite one, and different parts of the layer respond to different types of excitation. Further investigation in this field appears very promising.

The Rôle of surface in Colloids.—*By* J. N. MUKERJEE.

The colloidal state of matter owes its characteristic properties to the forces acting in a surface. In ordinary chemistry (organic and inorganic) one deals mainly with the isolation of chemical individuals, namely the molecules, their chemical composition and constitution. In physical chemistry one deals with properties of molecules in bulk, with equilibrium between the different states of aggregation and between different species of molecules. In all these instances we consider the energy of the system to be defined by the following variables:—

C_1, C_2,....the concentration of the different components and two external variables namely uniform pressure and temperature. The thermodynamic potential can consequently be expressed as of $f(C_1, C_2 .......P.T.)$.

But when we attempt to consider the properties of systems containing matter in a fine state of subdivision we find that deductions from the above assumptions do not hold good. We come across new variables or degrees of freedom as we can no longer neglect variations in surface energy. The concept of a specific surface or degree of dispersion thus becomes a necessity and we define the specific surface as the total surface per gram of the disperse phase.

The influence of the specific surface has long been known in the increase of vapour pressure of drops and in the increased solubility of powders with diminution in their radius. Similarly if we consider the energy of an interface to be entirely given by the product of the surface tension and its area we can conceive of a novel type of concentration changes in interfaces due to changes in surface tension with composition. Such considerations led W. Gibbs to deduce his well-known equations of the adsorption isotherm. J. J. Thomson pointed out that in virtue of surface energy new types of chemical combination may occur in the surface. We now know that the equilibria in the interface are quite different from that in the bulk of the reacting phases.

The physics and chemistry of colloids are however not so simple as to be explained by considerations of surface tension alone. The Gibbs' equation of adsorption does not lead us far as satisfactory experimental verifications are still lacking. Attempts have also been made to represent the behaviour of such systems as cellulose acetate in mixed solvents by including the degree of dispersion as a new variable. R. C. Tolman has extended Gibbs's phase rule to colloidal disperse systems by including the specific surface as an additional variable. He concludes that a system of finely disperse particles in a fluid can only be in equilibrium in the thermodynamic sense if the particles are all of the same size. Unfortunately this is seldom the case with colloids. This line of attack has not helped us much for the reason that in the majority of colloidal systems it can be reasonably doubted whether we are dealing with systems in stable equilibrium as understood in physical chemistry. Colloidal systems show very often hysteresis. Moreover if we are to consider the equilibrium conditions of every phase we must assume a much larger number of additional variables. Thus in an ordinary colloidal solution of gold or sulphur the particles are of different size, and we cannot speak of an equilibrium between the dissolved molecules and the particles in the ordinary sense. A carefully prepared sol with particles of practically uniform size does not show any characteristic difference in its stability relations or in its properties from an ordinary sol. which is polydisperse. The polydisperse sol if it be considered thermodynamically stable must have more than one additional variable to account for the differences in specific surface. However, though we have not been able to build up yet thermodynamic generalisations of the type of Gibbs's phase rule, applications of the principles of physics and of chemistry have been of material service in the study of colloids; conversely, the investigations of colloid systems have thrown a flood of light on the properties of interfaces and also to some extent on general physics and chemistry. We shall now briefly refer to some typical problems which will show how intimately the properties of an interface are interlinked with the properties of colloid systems.

The preparation of colloids by so called condensation methods involves the transition of a molecularly disperse substance to microscopic particles. We meet here the interesting subject of the kinetics of the formation of new interfaces or phases and shall refer in passing to the work of Weimarn and of Zsigmondy and their co-workers. We find that the number of the nucleii, the rate of deposition of fresh molecules or atoms at the surface and the total amount that separates, determine the size of colloidal particles as also the nature of the deposit in the electro-deposition of metals. The conditions affecting the formation of a new phase is of great importance in the phenomenon of zonal precipitations first studied by Liesegang.

The increased dispersion in the peptisation of a precipitate or in the formation of a stable emulsion requires work against capillary forces and though a low interfacial tension is favourable to its formation we must assume that there are other sources of changes in surface energy than surface tension. An interesting problem in the formation of emulsions is the inversion of types of which milk and butter can be cited as examples. We know how striking are the differences in the interface that determine the inversion of an oil-in-water type to a water-in-oil type of emulsion.

Such properties of colloids as the Brownian movement and their colour in transmitted and reflected light are also due to their large specific surface development.

There are two fundamental properties of colloids which are at present regarded to be the most important factors in determining their stability namely the electric charge and the hydration of the colloid particles or micelles. It happens that colloids can roughly be divided into two classes, one of which owes its stability mainly to the electrical charge of the particles, whereas the other owes its stability to a large extent to the degree of hydration of the micelles. There are of course systems representing transitional stages.

For the first group the most important questions are what is the origin of the charge and how do changes in the conditions of the system affect it? Investigations on this subject have enabled us to distinguish between different types of contact electrification. The potential drop supposed to exist between a metal and a solution of a salt of the metal with which it is in thermodynamic equilibrium is certainly different from that at the surface of colloidal particles. We might call the different types as the Nernst type and so on. This leads us to the subject of contact electrification in general which forms an interesting chapter in Physics.

Commensurate with the interest of so fundamental a property of colloids as its electrical charge we find a large variety of speculations regarding the nature of the adsorption of ions on the one hand and on the nature of the double layer on the other hand. It seems definite to me that we must distinguish between two types of adsorption of ions; namely, a primary adsorption of ions by the atoms on the surface due to their chemical affinity. To such an adsorped layer of ions a colloid surface owes its electrical charge. Secondly, there is an adsorption of oppositely charged ions by a charged surface due mainly to the electrical attraction exerted on them. From this point of view it is possible to give a consistent explanation of the effect of a constituent ion in determining the sign of the charge and in stabilising a hydrosol, of the great effect of polyvalent or complex ions of opposite charge in diminishing the stability, of the influence of electrolytes on endosmosis, the nature of the adsorption of electrolytes, the exchange of bases in soil, latent acidity in sour soil and other related phenomena.

One frequently finds in the literature the assumption that the adsorption of an ion by a surface mainly depends on its valency and chemical complexity and that the sign of the charge is not of much moment. It is overlooked that the adsorbability of an ion materially depends on the sign of the charge of the adsorbing surface. Similarly the assumption of independent adsorption of ions of opposite sign cannot explain the different types of curves in electro osmosis, cataphoresis and allied phenomena.

One particular topic in this subject is of great interest because of its theoretical importance, namely the reversal of the charge of a colloid surface by an electrolyte. Investigations on this subject are likely to decide between rival theories regarding the manner of distributions of the ions in the double layer.

Then there are the questions of hydration of charged surfaces and whether the ions are adsorped in a hydrated or in a dehydrated state. The speaker and Fajans have independently drawn attention to the adsorption of constituent ions by a precipitate and the factors that govern the intensity of the adsorption such as the lattice energy, the energy of hydration, or the chemical affinity as measured by the solubility product of the salt.

I think I have given sufficient indications of the properties of a surface we have to deal with in this field and I shall leave this topic simply pointing out that the adsorption of ions is only a chapter in the studies on adsorption.

Turning now to hydration, the other fundamental properties of colloids, we notice an obvious analogy to the usual phenomena of wetting of a glass surface by a liquid like water; a case again of adsorption as it is an interaction between molecules in an interface. It is however rather striking that the hydration of molecules or of colloid surfaces can be so great that a gel containing as much as 95% of water by weight is surprisingly elastic and behaves in many respects as a glass. 5 or 6% of gelatine will deprive the rest of the water molecules of their fluid character and give them a striking elasticity of shape. Regarding the general properties of the lyophilic class of colloids we might state that the changes in the properties of such systems are mostly changes in their degree of hydration. The hardening of gelatine by tannin, the precipitation of proteins at the iso-electric part are cases in point. Intimately connected with the hydration of colloid micelles and their charge are such questions as the permeability (selective or otherwise) of animal and vegetable cells. Living cells like bacteria and amoeba are more or less colloid particles or micelles with perhaps a complex movement depending on molecular collisions and on localised changes in surface and electrical tensions. Here also the electrical charge, the hydration and adsorption determine their properties.

A study of the hydration of gels in different solvents and mixtures of solvents have brought to light many interesting facts. We might mention here the observation that some gels can interchange molecule for molecule of water or alcohol or benzene. Of similar interest is the apparent analogy between solution and solation which is an extreme type of hydration. In the case of the electrolytic colloids the micelles are formed directly from the agglomeration of the insoluble aliphatic chain of the anion of the fatty acid. The electric charge and the hydration or solubility of the carboxyl group tend to keep the anions separate and in solution and the aliphatic part character tends to agglomerate and pass out of the enveloping water molecules to form an interface. In the case of gelatine the reactive groups at the surface perhaps tend to an arrangement of the micelles with respect to each other. These considerations bring us to the discussion of the forces that lead to an aggregation of colloid micelles. Here we have to take into consideration all types of cohesive forces from the chemical affinity of groups to ordinary capillary attraction.

It now remains for us to refer to the nature of the interface. A study of colloids suggests some fundamental speculations on the nature of the interface. Firstly what is an interface? The most satisfactory though vague definition would associate an interface with a new type of energy. As suggested in the beginning of this address whenever in discussing changes in the total energy of a system we have to consider energy changes dependent on factors other than the chemical composition or the external variables affecting the system as a whole, we must recognise the existence of interfaces in the system. A physical picture of such an interface must define the nature and the manner of variation of the forces working at the interface. In the case of a colloidal solution of gold it is clear that changes in the condition of the system are due to energy changes at the interface gold-liquid, but when we come to substances like gelatine or of the salts of the fatty acids are we not actually dealing with energy changes of the molecules? In pure chemistry the energy changes of the different species of molecules are all that we have to consider. Whether a molecule is hydrated or charged as in ions any change in its hydration or charge or in any of its conditions produces a corresponding change in its energy. Therefore if we have to assume the existence of interfacial energy or an interface for a huge molecule like that of gelatine it seems it might be equally justifiable to speak of changes in the interfacial energy of molecules in the common chemical reactions for the difference is after all one of degree.

This chemical point of view requires one important modification in so far as there is not sufficient justification to regard the energy changes of such a molecule as being due simply to chemical reactions of the surface groups. We have reasons to believe that the surface layer is not in all cases one molecule thick though it would appear that the first layer is undoubtedly in a large number of cases held with greater tenacity than the rest and that the chemical affinity of the surface atoms determine the intensity of adsorption of the first layer.

Amongst mathematical physicists, who have interested themselves with the nature of the interface there seems to be two schools of thought. Let us consider the simplest interface namely that of a pure liquid in contact with its saturated vapour. It is well known that in the Ramsay-Eötvos formula for the surface energy we define the molecular surface by the term $MV^{\frac{2}{3}}$ where v, is the volume of a sphere of unit mass of liquid and M its molecular weight in the liquid state. Evidently it is objectionable to compare a particular type of energy changes of a system if its mass dees not remain constant. Thus when we try to establish a relationship between the free or total surface energy and the heat of vaporisation we must always consider the transition of the same mass existing as a surface layer to the vapour state. Now the factor $MV^{\frac{2}{3}}$ does not represent a constant mass unless we assume that the interface is composed solely of the outermost layer of molecules of the liquid. This is actually the view of Einstein who assumes that the attraction of one layer of molecules does not extend beyond the next one and that the molecules in the immediate neighbourhood act as a sort of screen.

Just opposite is the view of the school of Dutch Physicists beginning from Van der waals. His pupils Hulshoff and specially G. Van Bakker have given a complex picture of the condition of molecules in the surface layer from this point of view. They assume a gradual transition from the liquid phase to the vapour phase over varying numbers of molecules depending on the temperature and the Van der Waals coefficients. According to Bakker the density of the surface layer is the mean of that of the liquid and vapour layers.

In this case the factor $MV^{\frac{2}{3}}$ can no longer represent a constant mass and the attempts for example by Whittakker and Kleemaun to correlate molar surface energy with heat of vapourisation etc. require modification.

We have seen that a clear knowledge of the physics and chemistry of surfaces is indispensable in the study of colloids.

Negative and Positive Catalysis and the Activation of Molecules.—*By* N. R. DHAR.

In 1811 Kirchhoff observed that mineral acids converted starch into dextrine and sugar but the acids themselves did not undergo any change.

More than a century ago Dobereiner showed that spongy platinum caused hydrogen to ignite in contact with air. Since then many facts have been added in the domain of catalysis and industrial developments have been made but hardly any substantial light has been thrown on the mechanism of catalytic reactions in general. In the following pages an attempt has been made to explain the mechanism and to unify catalytic phenomena (positive and negative) from considerations based on the formation of intermediate compounds. The importance of recent work of physicists on radiationless transfer of energy in the problem of activation of molecules and atoms and in catalysis in general, has also been emphasised.

Negative Catalysis.

In the following papers (Dhar Jour. Chem. Soc. 1917. *111*, 707: Proc. K. Akad Wetensch, Amsterdam 1921, *23*, 1074: Dhar and Mittra, Trans., Faraday Soc. 1922, *17*,) the subject of negative catalysis has been investigated and a mechanism of negative catalysis in several oxidation reactions has been suggested based on intermediate compound formation. The following lines of argument were advanced in those papers. The same considerations can be extended to several other cases of negative catalysis.

It is well known that a solution of sodium arsenite is not oxidised by atmospheric oxygen under ordinary conditions. On the other hand, a solution of sodium sulphite is readily oxidised to sodium sulphate. If we mix the two together and expose the mixture to air or oxygen the oxidations of arsenite and of sulphite go on simultaneously. At the same time a curious phenomenon takes place—the velocity of the oxidation of sodium sulphate becomes very small in presence of sodium arsenite. In other words sodium arsenite which is undergoing a slow oxidation acts as a powerful negative catalyst in the oxidation of sodium sulphite. Similary the solution of an oxalate which also undergoes slow oxidation in presence of sodium sulphite, which is itself being oxidised, slows down to a marked extent the oxidation of sodium sulphite by atmospheric oxygen, moreover we have observed that manganous hydroxide, ferrous hydroxide and sodium thio-sulphate which are slowly oxidised by passing oxygen in presence of a solution of sodium sulphite markedly retards the oxidation of sodium sulphite. Also ferrous salts retard the oxidation of stannous salts in air. It appears probable therefore, that the phenomenon of negative catalysis in oxidation reactions is possible only when the catalyst is liable to be oxidised. I have observed that manganous salts act as powerful negative catalysts in the oxidation of formic and phosphorous acid by chromic acid and manganous salts easily pass into the manganic state. Moreover it has been shown by various investigators that organic substances notably quinol, brucine, sugars and other reducing agents act as negative catalysts in the oxidation of sodium sulphite by oxygen. It is well known that the oxidation of phosphorus by oxygen or air is retarded by the vapours of various organic substances, e.g. ether, alcohol, turpentine, etc. and the oxidation of chloroform is retarded by the presence of a small quantity of alochol.

According to Moureu and Dufraisse (Compt. rend. *174*, 258, *175*, 127, 1922), a trace of quinol can suppress the oxidation of benzaldehyde. Moreover Lifschitz and Kalberer (Zeit. Phys. Chem. *102*, 393, 1922) have shown that ether retards the slow oxidation of various magnesium alkyl halides of the Grignard type, which oxidation is revealed by luminescence on exposure of the substance to air. Similar retardation has been observed by Delēpine (Bull. So. Chim. France *31*, 762, 1922) in the oxidation of organic suphur compounds by air.

Now all these negative catalysts are good reducing agents and are themselves readly oxidised. Hence in oxidation reactions, the phenomenon of negative catalysis takes place when the catalyst itself is liable to be readily oxidised.

Schonbein first noticed that when certain substances are undergoing oxidation spontaneously by atmospheric oxygen, one part of the oxygen combines directly with the substance undergoing oxidation—whilst another part of it, is converted into ozone, hydrogen peroxide or simultaneously oxidises some other substance. Schonbein, still further demonstrated that just so much oxygen is rendered active as is consumed by the substance which is being oxidised; or in all slow oxidations the same amount of oxygen is required as is consumed in the formation of hydrogen peroxide from water or is consumed in the induced oxidation. Later investigators like Jorissen, Engler and Wild have verified the law of Schonbein, in several cases If we expose a mixture of sodium sulphite and arsenite to atmospheric oxygen, according to Schonbein, one atom of oxygen should go to oxidise sodium sulphite, while the other oxygen atom would oxidise a molecule of sodium arsenite in the same time. The oxidation of sodium arsenite is a very slow chemical change and in order that Schonbein's law be applicable it follows immediately that the oxidation of sodium sulphite, which is farily rapid should become a slow change and the velocity of this oxidation should become equal to that of the oxidation of sodium arsenite by oxygen, because the same amount of oxygen will be taken up by the reducing agent at the same time. As a matter fact from our experiments we find that in presence of sodium arsenite or potassium oxalate, or ferrous hydroxide or manganous hydroxide, the velocity of oxidation of sodium sulphite by air becomes very small. We assume that a molecule of oxygen splits up in this reaction into two atoms and each atom oxidizes one of the reducing agents. Now as a solution of the sodium sulphite is much more readily oxidized than a solution of sodium arsenite, it becomes difficult to understand why the other oxygen atom instead of attacking the readily oxidizable unattacked sodium sulphite, prefers to react on the much more difficultly oxidized sodium arsenite, or if we assume that at first tho peroxide of the type of Bödlander's benzoyl peroxide is formed as a combination of the sodium sulphite with a molecule of oxygen, we are still encountered with the same difficulty. In this case we shall have to assume that this peroxide instead of attacking the readily oxidizable sodium sulphite will react on the less readily oxidizable sodium arsenite by preference. It seems, therefore, that the only course left to us is to find out the explanation in theory of the formation of a complex of sulphite and arsenite or of sulphite and oxalate and that this complex is oxidized as a whole. It is well known that complex sulphites and oxalates do exist. I have observed in a previous paper (Proc. K. Akad. Wetensch, Amsterdam 1920, *29*, 479) that in the oxidation of sulphites and sulphurous acid the sulphite ion is the active agent. If we decrease the concentration of the sulphite ion we can decrease the rate of the chemical change, and a solution of H_2SO_3, which is a weak acid containing few SO_3 ions, is oxidised less readily than a solution of sodium sulphite of the same concentration. On the addition of an arsenite to a sulphite a complex which itself is oxidized as a whole is formed, at the same time the velocity of oxidation of sulphite becomes less due to the decrease in the concentration of the sulphite ions arising out of the formation of a complex of arsenite and sulphite or of SO_3'' and an oxalate. Hence it seems that the only plausible explanation of negative catalysis in oxidation reactions stands on the theory of formation of unstable intermediate compounds of the catalyst and one of the reacting substances. These views were advanced more than 3 years ago. (Dhar, Proc. K. Akad. Wetensch 1921, *23*, 1074) In a recent paper Taylor has come to similar conclusions with regard to the retarding influence of water on the decomposition of oxalic acid by concentrated sulphuric acid, decomposition of diazo-acetic ester, etc. (Jour. Phys. Chem. *27*. 322, 1923). Consequently the concensus of opinion at the present moment is in favour of the view that intermediate compounds are formed in the phenomenon of negative catalysis.

From considerations based on chemical dynamics Ostwald criticised adversely the conception of intermediate compound formation in the explanation of catalytic phenomena. He advanced the argument that in order to explain positive catalysis by the theory of intermediate compound formation, it was necessary to show that the intermediate reactions actually took place more readily than the direct reaction under the given conditions; because if a reaction proceeded more slowly through an intermediate product than the direct path, it would take the latter and the possibility of intermediate products could have no influence on the process. "Hence" added Ostwald "I see no possibility of explaining retarding catalytic influence by the intermediate products" (*Nature* 1902, *65*, 522).

My arguments in favour of the view of intermediate compound formation as an explanation of negative catalysis have already been put forth and they are certainly based on consideration of the velocity of chemical changes involved.

In a foregoing paper (Dhar. Jour. Chem. Soc. 1917, *111*, 707) it has been proved that the oxidation of sodium formate by iodine is a bimolecular reaction and the change takes place according to the following equation $H.COONa + I_2 = HI + NaI + CO_2$. The iodine is dissolved in potassium iodide. The reaction is retarded by iodide ions and hence there is a slight lowering of the velocity coefficient as the reaction proceeds due to the continued increase in the concentration of the iodide ions which are products of the reactions. One peculiar point has been observed namely, that if there is a definite concentration of potassium iodide, the velocity coefficient does not depend on the concentration of iodine, but if we start with a definite concentration of iodine and increase the concentra- of KI, the velocity coefficient falls off.

This effect cannot be explained from the mass action equilibrium $KI + I_2 \rightleftarrows KI_3$. When we use 1·27 grams of iodine and 5·4132 grams of KI we get k_1 at 25° = 0·00196 and when we use 0·635 grams of iodine and 2·7066 grs. of KI, k_1, becomes 0·00378. The concentration of sodium formate in these two cases are equal and according to the mass action equilibrium the velocity coefficient should be the same.

Similarly the oxidation of sodium formate by $HgCl_2$ is retarded by chloride ions. From the experimental results it has been observed that in this case also the velocity coefficient was independent of the concentration of $HgCl_2$. If however the effect of the chloride be simply to form a complex with mercuric chloride, $HgCl_2 + RCl = RHgCl_3$, the velocity coefficient would naturally depend on the concentration of $HgCl_2$ The oxidation of potassium oxalate by iodine is also retarded by iodide ions. Similarly the oxidation of potassium oxalate by $HgCl_2$ is retarded by chloride ions.

All these oxidation reactions are retarded by hydrogen ions, because in these oxidations the formate and oxalate ions are taking part. Similary we have proved that in the oxidation of sodium sulphite by air the sulphite ions are active.

These cases of negative catalysis are similary to those on the influence of HBr on the hydrolysis of bromosuccinic acid studied by Muller (Zeit. Phys. Chem. *41*, 483, 1902) and on the hydrolysis of several organic halogen acids studied by Senter and Porter (Jour. Chem. Soc. *99*, 1049, 1910)

Temperature coefficients of catalysed and non-catalysed reactions.

From my researches on the temperature coefficients of thermal and photochemical reactions the following general results have already been established:—

1. A positive catalyst diminishes and a negative catalyst increases, the temperature coefficient of a reaction, the decrease or increase being the greater, the higher the concentration of catalyst.
2. When light acts as an accelerator, the temperature coefficient

of a reaction carried on in light is smaller than that of the reaction in the dark.

3. Reactions which are very sensitive to the influence of temperature are also sensitive to the influence of light.

4. The simpler the order of a reaction, the greater is its temperature coefficient. In other words uni and bimolecular reactions have higher temperature coefficient than multimolecular ones.

Physiological processes mostly take place in heterogenous medium. The Brownian movement of the colloidal particles present in the reacting substances does away with the diffusion layer characteristic of heterogenous reactions, and makes the physiological processes similar to positively catalysed reactions taking place in homogeneous medium. Consequently the temperature coefficients of physiological processes (instead of being small namely about 1·2) are generally greater than 2 for a 10° rise.

In calculating the temperature coefficient of a reaction the Arrhenius formula $\log \frac{k_1}{k_2} = \frac{A(T_1 - T_2)}{T_1 T_2}$ is applied. Consequently the value of a temperature coefficient for a 10° rise becomes smaller as the temperature rises. Experimental results on the determination of temperature coefficients of chemical reactions have always supported the conclusion that the temperature coefficient becomes smaller as the temperature rises. Consequently, in all my work on the temperature coefficients of catalysed and uncatalysed reactions comparisons of temperature coefficient have been made between the same temperature interval.

On page 332 of Taylor's paper (loc. cit.) the following occurs in connection with temperature coefficient of the action of strong sulphuric acid on oxalic acid in presence of a trace of water. "Therefore the temperature coefficient of the whole decomposition process should diminish with increase of water content in the solution. This is actually the case. The higher value, 4·42, of the temperature coefficient is for a dilution of 0·1% water in the interval 25-35°C At 70-80°C for a 3% water concentration, the temperature coefficient of 3·35 is obtained." I have already said that the temperature coefficient of a chemical change falls off as the temperature rises. If we calculate according to the Arrhenius formula, the temperature coefficient between the interval 70-80°C with 0·1%water concentration in the decomposition of oxalic acid by sulphuric acid we get a value 3·08 which is less than that obtained with 3% water concentration between 70-80°C (3·35). Hence the conclusion of Taylor is erroneous. These results of Bredig and Lichty can be readily explained on our theory that a negative catalyst increases the temperature coefficient of a reaction. Water is a negative catalyst in the above reaction and the greater the concentration of water the greater is the retardation and consequent increase in the temperature coefficient.

Consequently in presence of 3% water the temperature coefficient of the reaction between oxalic acid and sulphuric acid should be higher than that with 0·1%water. The results of Bredig and Lichty are in agreement with our general conclusions already cited.

There is a difficulty with regard to the action of sulphuric acid on oxalic acid, the reaction is represented as $H_2C_2O_4 + H_2SO_4 = H_2O + CO + CO_2 + H_2SO_4$. Bredig and Lichty have shown that the chemical change follows the unimolecular formula. The negative catalyst water is being continually formed as a product of the chemical change; consequently the unimolecular coefficients instead of remaining constant should decrease as the change proceeds. Similarly Meyer's work (Zeit.Elektrochem 1909. 15, 506 on the reaction between formic acid and sulphuric acid show that an unimolecular coefficient is obtained although the negative catalyst water is being continually formed in the system.

Experimental work is in progress in these laboratories to settle these points and other cases of positive and negative catalysis.

Some comment should be made on accepted views about the temperature coefficients of photochemical reactions. Hitherto the opinion has been generally held that in light the temperature coefficient of photochemical reactions should be about unity. On the contrary my researches prove that the temperature coefficient of a reaction occurring in light may have any value but it will be smaller than that of the reaction in the dark if light accelerates the change. The diminution of temperature coefficient depends on the acceleration of the reaction in light. (Dhar. Jour. Chem, Sec. 1923 *123*, 1856.)

It is well known that if light of definite wave lengths fall on metals like Na, K, Cs etc., electrons are given out at ordinary temperatures. The photoelectric emission of electrons is hardly affected by increase of temperature. On the other hand thermoionic emission is greatly increased by increase of temperature. Ordinarily chemical reactions carried on in the dark are expected to obey the same laws as governed the emission of electrons from heated substances, whilst ideal photochemical changes should follow the same laws as are applicable to photoelectric emission. In reality, ideal photochemical reactions are very rare and that is why, temperature coefficients of many photochemical reactions are usually greater than unity.

Positive catalysis and its mechanism and the activation of substances.

In many cases of positive catalysis consistent explanations can be given of the phenomena if we assume that intermediate compounds are formed. Let us take the decomposition of potassium chlorate by heat in presence of $Mn0_2$ and other manganese salts. If ordinary $KCl0_3$ is heated till it melts and is allowed to cool the solid usually shows a light pink colour. The reason of the pink colour is this:—the chlorate ordinarily is obtained from chlorine prepared by the Weldon method and the chlorine thus prepared carries with it a little manganous salt. Hence the potassium chlorate is contaminated with a little manganous salt. If the potassium chlorate is fused the manganous salt is changed into permanganate by oxidation with $KClO_3$ and hence the pink colour. Several years ago McLeod (Jour. Chem. Soc. 1889, 55,184) threw out the suggestion that possibly pot-permanganate would be an intermediate stage in the decomposition of $KCl0_3$ in presence of MnO_2 by heat, but he could not actually obtain any permanganate by using $KCl0_3$ and $Mn0_2$. By utilising $MnSO_4$ instead of $Mn0_2$ as a catalyst we have been able to obtain $KMn0_4$ directly as an intermediate substance in the decomposition of $KCl0_3$ in presence of manganese salts. Quantitative experiments are in progress in this laboratory, which show that appreciable quantities of $MnSO_4$ are converted into $KMn0_4$. When $MnS0_4$ is added to $KCl0_3$ which has just melted $KCl0_3$ does not begin to decompose till it attains the temperature of about 450°C whilst $KMn0_4$ decomposes at about 250°C. Consequently the ready decomposition of $KCl0_3$ when it is just melted in presence of $Mn0_2$ or manganous salts is readily explained. The intermediate product $KMn0_4$ which is formed decomposes at the melting temperature of $KClO_3$.

It is well known that in the Chamber process of manufacture of H_2SO_4, the SO_2 is very readily oxidized by nitrogen peroxide which is obtained by the action of oxygen on nitric oxide. In this as well as in the previous cases, the activation of the chemical changes involved can be readily explained on the theory of the formation of intermediate substances which favour the chemical changes. The velocity of oxidation of SO_2 by molecular oxygen is small whilst through the intervention of nitric oxide which in its turn becomes converted into nitrogen peroxide, the speed of the oxidation of the SO_2 is increased.

In the contact method of H_2SO_4 manufacture, the speed is increased by spongy platinum, or platinised asbestos, platinum black or any other substance of this type.

What is the mechanism of this activation? If we can assume that the catalyst platinum black converts a molecule of oxygen into oxygen atoms, then the mechanism would have been clear, because an atom of oxygen is certainly more active than a molecule of the same substance. When a molecule is converted into atoms it takes up energy. Thus about 80000 calories of heat are necessary to atomise a molecule of hydrogen. What is the origin of this energy? If the adsorption of oxygen by platinum black could take up heat, then we could have imagined that the amount of heat taken up would be utilized in the formation of oxygen atoms, but as a matter of fact when gases are adsorped by substances like platinum, charcoal Pd etc., heat is given out instead of being absorbed. From the researches of Favre (Ann. Chim Phys (3), *37*, 465, 1853) Mond, Ramsay and Shield (Proc. Roy. Soc. 1897, *62*, 50, 290,) and others, we know that large quantities of heat are given out when NH_3 is absorbed by charcoal or hydrogen by palladium Platinum etc. Hence we cannot imagine that hydrogen is converted into the atomic state when it is absorbed by palladium or that the oxygen is converted in the atomic state, when adsorbed by platinum black. Very recently, however, Richards and Richards (Jour. Amer. chem. Soc. 1924, *46*, 89,) have suggested that hydrogen occluded in iron is in the atomic condition. Also compare Langmuir (Jour. Amer Chem. Soc. 1912, 34, 1310.)

In explaining hydrogenation reactions, Sabatier and others, assume that with metals like Nickel, hydrogen forms an unstable hydride like NiH_2 or Ni_2H_2 and this hydride is capable of giving out atomic hydrogen which is more active than the molecular variety (Sabatier, La catalyse en chimie organique, 1920, p. 60). Very recently, Schlenk and Weichselfelder (Ber. 1923, *56* (B) 2230) have brought further evidence in support of the view that NiH_2 is formed in these hydrogenations.

If we pass hydrogen through a solution of $FeCl_3$ we find that the ferric chloride is not reduced to the ferrous state but if we add a little palladium foil to the solution it will convert the ferric salt to the ferrous state. Similarly Oxygen adsorbed by platinum black is more active than molecular oxygen and can readily oxidize ethyl alcohol, fermic acid, oxalic acid, etc.

How these molecules are activated? How can the adsorption process activate these molecules? Our knowledge about metallic hydrides has considerably increased during the last few years (compare Jaubert Comptes-rend. 1906, *142*, 788 Moers, (Zeit. Anorg. Chem. 1920, *113*, 179) and others). Recently Peters (Zeit. Anorg. Chem. 1921, *131*, 140) has proved that hydride of Li. can be electrolysed in the fused condition and hydrogen is evolved at the anode and the metal at the opposite electrode. We can imagine that when H_2 is passed over finely divided nickel or through palladium, an unstable hydride is formed and this hydride decomposes into the metal and hydrogen in the atomic or in an active condition, which is capable of inducing the process of hydrogenation involved. Unfortunately there is no direct experimental evidence in support of this view. In order to avoid this difficulty, Bancroft (Jour. Phys. Chem. 1917, *21*, 571,) explains these cases on the view of increased concentration of one or more of the reacting substances at the surface of the catalyst due to adsorption. He explains most cases of contact catalysis in heterogenous systems on this increase of concentration.

Let us take the case of the reaction between SO_2 and oxygen again. Instead of ordinary catalysts, light may be utilized in activating the oxygen molecules. We have observed that if SO_2 and O_2 are exposed in glass vessels to tropical sunlight, crystals of SO_3 are obtained at the ordinary temperature. We can imagine that the light of the sun has activated the oxygen molecules which have reacted with the sulphur dioxide at the ordinary temperature. It is difficult to state at this stage whether the light converts the oxygen molecules into an active form or into atoms (Compare the work of Wendt, Landaour and Ewing Jour Emer. Chem. Soc. 1922, *44*, 2327 on the activation of Chlorine by light.)

In this connection the recent work of physicists on radiationless transfer of energy would be interesting. The experiments on ionisation potential first carried out by Franck and his colleagues (Berk. Dent. Physikal Ges. 1913, *15*, 34, 373, 929, 1914, 16-457) are now well-known They deal with interchange of energy between freely moving electrons and atoms. A stream of electrons moving with a definite velocity is projected into a mass of gaseous matter, when an electron happens to pass close to an atom, then provided the energy of the free electron exceeds a certain limit, the whole of its energy may be transferred to the valency electrons lying at the outer periphery of the atom. The valency electron is therefore uplifted to higher quantum orbits. This state is not stable and in a short time reverts to its original position. The excess of energy being set free as monochromatic radiation. Thus the atoms take away energy from the free electrons and convert it into its own energy of monochromatic radiation. When the energy of the bombarding electron is sufficiently large it may tear up the valency electron from the parent atom. This stage is known as "ionisation." Hitherto attention of all workers has been confined to only one side of the problem, namely communication of energy from the free electron to the atom. But Klein and Rosselund (Zeit. Physik, 1921, *41*, 46) showed that the reverse process, namely communication of energy by an excited atom to a free electron actually takes place in many cases, e.g. a mass of mercury atoms, some of which have been activated either by absorption of light $\gamma=2536$, or by the electric discharge, and if an electron passes close to it the mercury atom may transfer its energy ($\lambda=2536$) to the electron. The electron thus receives an increment in its velocity but the transfer is radiationless. The electron chokes the emission of light $\lambda=2536$ These observations further extended by Franck and his students (Zeit. Physik, 1922, *9*, 259; *11*, 161 : 1923, *17*, 202) who showed that the excited atom may communicate their energy not only to the electron but also to such atoms and molecules which may come into their contact. These atoms or molecules will therefore receive either some increment in their kinetic energy or if the energy imparted be sufficiently large they may be excited to their spectral emission, ionisation or dissociation in the case of molecules. These ideas therefore open out a very promising field of investigation. For example Franck activated a stream of mercury vapour by light $\lambda=2536$ and these activated mercury atoms were allowed to act upon hydrogen gas. It was proved that gaseous hydrogen was converted into atomic state even at a temperature of about 40°C. This atomic hydrogen was capable of converting cupric oxide into the cuprous state at such a low temperature as 40°C, at which temperature molecular hydrogen cannot reduce cupric oxide. The explanation is that when a mercury atom absorbs light $\gamma=2536$ it is loaded with an energy content of 4·9 volts. On coming in contact with hydrogen molecules which are thereby broken into atoms as the heat of dissociation of hydrogen is about 80,000 calories which corresponds to 3·8 volts.

It seems from these results that the active nitrogen of Lord Rayleigh (Strutt. Proc. Roy. Soc. 85A [1910. 219; *86*A (1911). 56, 252: *87* (1912). 179] ozone, active hydrogen, active chlorine, etc. may be supposed to be really activated nitrogen, activated oxygen, activated hydrogen, activated chlorine, from the point of view of Franck. When a moderately condensed electric discharge is sent through nitrogen gas, it is converted into an excited state falling short of dissociation into its constituent atoms. According to this view active nitrogen is probably excited nitrogen molecule loaded with a certain voltage. Its great activity is due to the ease with which these active molecules give out this extra amount of energy. We all know that ozone is formed by passing silent electric discharge through oxygen, we can therefore imagine that the so-called substance ozone is nothing but oxygen in an excited condition and charged to a certain voltage. It is well known that ultra-violet light can convert oxygen into ozone. Recently Weiser and his colleagues (Jour.

Phys. Chem. 1921, *25*, 61, 349 473) and Downey (Jour. Chem. Soc. 1924, *125*, 347) have proved that the glow of phosphorus in oxygen gives out ultra violet light and this ultra violet light converts oxygen into ozone. From the point of view of Franck we know that mercury vapour can be excited by electric discharge as well as by light of $\lambda = 2536$.

Consequently we can imagine that oxygen is also activated and is changed to a certain voltage by silent electric discharge or by ultra-violet light. Similarly the active forms of gases like hydrogen, chlorine, etc. prepared by Wendt and colleagues (Jour. Amer. Chem. Soc. 1920, *42*, 930), Venkataramaih (Jour. Phys. Chem. 1923, *27*, 74) compare Lowry Jour. Chem. Soc., 1912, *101*, 1152; Koenig and Elöd. Ber. 1914, *47*, 576 and others)—are probably activated molecules of these gases and charged to be a certain voltage and their activity is due to the readiness with which they can give out this extra amount of energy and hence can induce many chemical changes which these cases in molecular condition cannot effect. It is well known that when silent electric discharge is passed through oxygen, there is a contraction in volume. Hence it appears that the active forms of oxygen occupies less space than molecular oxygen. Similar contraction in volume has been observed by Venkataramaih [loc. cit. also Nature *106* (1920), 46] when silent electric discharge is passed through chlorine. It is impossible to say whether active nitrogen occupies less space than molecular nitrogen because Lord Rayleigh has not studied this question, just as in the case of activation of oxygen or chlorine, there is a contraction in volume, it is probable that in the formation of active nitrogen there will also be a contraction in volume. Lord Rayleigh has shown that active nitrogen gives a glow. It is probable that this glow is due to the reversion of the active variety into the inactive molecular form.

In this connection, it will be interesting to consider the phenomenon of phosphorescence from these points of view. For example when calcium sulphide is exposed to light, it absorbs light energy and becomes converted into an active form and is charged to a certain potential. In the dark, this activated calcium sulphide would pass into the inactive form and would give out light. It is needless to point out that the active condition of matter is certainly an unstable state of affairs and its natural tendency will be to revert to the stable inactive form. There is a striking analogy between the after glow of active nitrogen and the phenomenon of phosphorescence ordinarily observed. Lord Rayleigh (loc. cit, also Proc. Roy. Soc. 1915 A *91* 303,) Tiede and Domcke (Ber. 1914, *47*, 2283) Pirani (Chem. Zentr. 1921, i, 200) and others have shown that absolutely pure nitrogen does not give an after glow. Traces of H_2S, oxygen, SO_2, etc. are necessary for obtaining an appreciable after glow. Similarly it is well known that the phenomenon of phosphorescence is also associated with traces of impurities in the phosphorescent substances. It seems therefore that there is some similarity between the after glow of active nitrogen and the phosphorescence of ordinary substances. Similarly we can imagine that emanations from radio-active substances can activate molecules of Barium Platino sulphide or zinc sulphide and these activated molecules become phosphorescent when they revert to the inactive variety.

The glow due to the slow oxidation of phosphorus has attracted the attention of numerous workers. Recently luminescence has also been observed in the slow oxidation of magnesium alkyl halides (Lifschitz and Kalberer, loc cit.) and of organic sulphur compounds (Delèpine loc. cit.). It is well known that ions are generated in the slow oxidation of phosphorus and it is very likely that ions would be generated in the other cases of slow oxidations causing luminescence. The ions, in their turn, would convert ordinary oxygen into the activated condition which would readily oxidize substances. Now the conversion of the active form into the inactive variety would cause the luminescence. Recently Downey (loc. cit.) has shown that the light given out in the oxidation of phosphorus contains short wave lengths and is rich in ultra-violet rays. It will be very interesting to compare the spectrum of this light with that due to the slow oxidations of magnesium alkyl compounds and of organic sulphur compounds. The spectrum of active nitrogen of Strutt has been studied by Fowler and Strutt (Proc. Roy. Soc. 1911, A 85, 377) and it consists of the usual α, β and γ groups of positive bands and contains ultra-violet radiations. I venture to suggest that the ions given out in the slow oxidation of phosphorus, magnesium alkyl compounds, organic sulphur compounds, etc which would activate the molecular oxygen present there. This activated oxygen would give all the tests attributed to ozone. A part of the activated oxygen without effecting oxidation and hence giving out its extra amount of energy to the oxidizable substance, would spontaneously pass into the inactive variety and would give light rich in ultra-violet rays, which can activate other molecules of oxygen. This is probably the origin of the glow obtained in the slow oxidation of phosphorus, magnesium alkyl halides, organic sulphur compounds, etc. I am of opinion that in these slow oxidations, ions are first produced as products of the chemical change and not due to the glow as suggested by Downey (loc. cit).

Very recently Chapman and Davies (*Nature*, 1st March 1924, p. 309) have shown that when oxygen or hydrogen is driven into fused quartz by the electric discharge, the quartz acquires the property of phosphorescing.

This phenomenon seems to me to be the same as that studied by Lord Rayleigh in connection with active nitrogen. The gas hydrogen or oxygen absorbed by quartz becomes active by the electric discharge. The phosphorescence is very likely due to the reversion of the active form into the inactive variety. Rayleigh observed that active nitrogen glowed more intensely at the temperature of liquid air than at the ordinary temperature. Chapman and Davies have also observed that a small area of the tube cooled with liquid air while the discharge is passing that area glows much more brightly than the rest of the tube after the discharge has been stopped.

Consequently like Rayleigh, Chapman and Davies have got active forms of hydrogen and oxygen. It will be interesting to find out whether nitrogen can be activated in this manner. Moreover it is worth while comparing the spectrum of the light given out by oxygen in its phosphorescence by this method and that of the light given out in the slow oxidation of phosphorus, magnesium alkyl compounds, organic sulpher compounds, etc. It seems likely that the spectra of the lights given out in all these phenomena would probably be alike, because according to the views advanced in this paper, the glow is supposed to be due in all cases to the transformation of activated oxygen (in one case made energetic by the electric discharge as in the experiments of Chapman and Davies, and in the other cases activation is due to the ions first given as products of the chemical changes involved) to the inactive molecular oxygen with loss of the extra amount of energy.

It is well known that ions are generated in the oxidation of phosphorus. It is very likely that these ions can activate molecules of oxygen, which thus become reactive and induce chemical changes which are not possible with molecular oxygen. Emission of electrons and ions in many chemical reacitions has been observed by Haber add Just (Ann. Physik. 1911, (iv) 308), Pinkus and de Schulthess (Jour. Chim. Phys. 1920, *18*, 366; Helv. Chim. Acta 1921, *4*, 288), Richardson (Phil. Trans. 1921, (a) *222*, 1) and others. Moreover, Potter (Proc. Roy. Soc. 1915, *91*, 465) has shown that carbon dioxide liberated during fermentation of glucose through the action of yeast carries both positive and negative ions.

If it can be definitely proved that ions are generated in all slow oxidations, then the phenomenon of induced oxidation will be readily intelligible. For example, let us take the case of the mixture of sodium sulphide and sodium arsenite. If the spontaneous oxidation of sodium sulphite by air or oxygen can generate ions, these ions would activate the molecules or atoms of oxygen, which can then react on the molecules of sodium arsenite.

Moreover, if it is generally proved that ions are produced in slow chemical changes, a flood of light would be thrown on many complicated induced reactions. In a foregoing paper (Dhar, Jour. Chem. Soc. 1917. *111*, 697) I have proved that the oxidation of oxalic acid by mercuric chloride is activated by the oxidation of the same substance by permanganate. Thus a solution of oxalic acid is not oxidized by mercuric chloride even in the boiling condition, but if a few drops of potassium permanganate is added to the mixture the permanganate oxidizes some oxalic acid and at the same time mercuric chloride oxidizes. Oxalic acid and mercurous chloride comes out as a precipitate. If we can prove that in the reaction between permanganate and oxalic acid, ions are produced and these ions would activate the molecules of oxalic acid which would reduce mercuric chloride because of its increased energy, then the mechanism of induced reactions of these types would be intelligible.

Moreover, it will be worth while investigating whether ions or electrons are given out when gases like hydrogen or oxygen, etc. are adsorbed by platinum, palladium, etc. the ions produced would activate the molecules and would make the chemical change proceed quickly. If this is so, it would explain the catalytic effect of platinum, palladium, nickel in chemical changes.

Summary and Conclusion.

(1) Experimental results show that in oxidation reactions the phenomenon of negative catalysis takes place when the Catalyst is liable to be readily oxidized.

(2) The mechanism of negative catalysis in oxidation reactions can be explained on the theory of the formation of intermediate compounds of the catalyst and one or more of the reacting substances.

(3) A positive catalyst diminishes and a negative catalyst increases, the temperature coefficient of a reaction, the decrease or increase being the greater, the higher the concentration of the catalyst.

(4) When light acts as an accelerator, the temperature coefficient of a reaction carried on in light is smaller than that of the reaction in the dark.

(5) The temperature coefficient of photochemical reactions need not be about unity in all cases, but it may be much greater than unity as shown from experimental results.

(6) Thermal reactions carried on in the dark are expected to obey the same laws as govern the emission of electrons from heated substances, whilst ideal photo-chemical changes should follow the same laws as are applicable to photo electric emission.

(7) Intermediate compound formation can explain many catalytic accelerations.

It is proved experimentally that potassium permanganate which is more readily decomposed than potassium chlorate is an intermediate compound in the decomposition of potassium chlorate in presence of MnO_2 and mangnous salts by heat.

(8) When gases are absorbed by Pd. Pt. charcoal, etc heat is given out, hence it is difficult to assume that the gases are converted into the atomic state by adsorption.

(9) It is suggested that active nitrogen, ozone, active hydrogen, active chlorine, etc. are activated by electric discharge or by light and loaded with a certain voltage. Their great activity is due to the ease with which these activated molecules give out the extra amount of energy.

(10) The glow of active gases like nitrogen, hydrogen oxygen, etc.

the phenomenon of phosphorescence caused by light, the phosphorescence caused by radium emanation, etc. are supposed to be due to the reversion of the activated forms of these substances into the inactive variety with the loss of the extra amount of energy.

(11) All slow oxidations are likely to give out ions and electrons, which could activate the molecules of oxygen. This activated oxygen would give all the tests attributed to ozone. A part of the activated oxygen would spontaneously pass into the inactive variety and would give out light. This is probably the origin of the glow obtained in the slow oxidation of phosphorus, magnesium alkylhalides, organic sulphur compounds etc.

(12) It seems probably that the ions generated in slow oxidations, could activate molecules of oxygen, which thus become reactive and induce chemical changes which are not possible with molecular oxygen. For example if the spontaneous oxidation of sodium sulphite by air or oxygen can generate ions which would activate oxygen molecules and these active molecules can then react with sodium arsenite. Other induced reactions can be explained in a similar way.

(13) It seems worth while investigating whether ions are given out when gases are absorbed by Pt, Pd, Ni, etc. If ions are given out during adsorption of gases this will explain the catalytic effect of these substances.

Induced oxidation and the explanation of the internal use of iron salts and of fever.

Since the days of Lavoisier, the phenomenon of slow oxidation has attracted numerous workers, especially because the great biological phenomenon of life mainly depends on slow oxidation

The immortal chemist Lavoisier was the first to apply the balance and the thermometer to the investigation of the phenomenon of life and he declared in 1780 "La vie est une fonction chimique." The work of to-day is but the continuation of that done a century and more ago. Lavoisier and Laplace made experiments on animal heat and respiration. Lavoisier declared that life processes were those of oxidation with the resulting elimination of heat. The fundamental fact that the quantity of oxygen absorbed and of carbon dioxide given out depends primarily on (1) food, (2) work and (3) temperature, was established by Lavoisier within a few years after his discovery that oxygen supported combustion. Writing in 1849 Regnault and Reiset remarked "Les recherches modernes out confirne ces vues profondes de. l'illu stre savant." It was however, quickly noted that if carbon and hydrogen burn in the lungs the greatest heat would be developed there, a result not in accordance with observation. It was then suggested that the blood dissolves oxygen and that the production of carbon dioxide and water took place through oxidation within the blood. Through the critical studies of Liebig which were published in 1842 it was observed that it was not carbon and hydrogen which burn in the body, but protein, carbohydrates and fat; it was also proved that the amount of oxygen needed in metabolism depends upon the chemical composition of the material that burns in the organism.

Rubner showed that if the diet were increased from a medium to an abundant supply the metabolism as indicated by the heat production increases.

The fact that food materials not affected by molecular oxygen at ordinary temperatures are oxidised with the greatest ease within the animal body into their end products is a really wonderful phenomenon. One can at once realise how remarkable this is by reflecting upon the intense heat required to burn completely a bit of protein upon a platinum foil, although it is extremely easy for the body to break down a large quantity of protein.

Traube seems to have been the first to adopt the idea of an oxidising ferment and to give expression to the happy idea that there occur in the body readily oxidisable substance which have the power of transferring the oxygen in active form to substances which are oxidisable with difficulty such as the food materials.

We have been successful in imitating these biological processes in the laboratory.

In studying induced reactions we have found out that substances like starch, cane sugar, etc., which are not directly oxidised at ordinary temperatures by atmospheric oxygen, can be oxidised by the same agent when they are mixed with substances like sodium sulphite or freshly precipitated ferrous hydroxide, which themselves undergo oxidation in air. Thus oxidation has been induced in the following substances in presence of Na_2SO_3 or freshly precipitated $Fe(OH)_2$:—Urea, starch grape sugar, cane sugar, $K_2C_2O_4$. CH_3COONa, Sodium potassium tartrate, sodium formate, sodium citrate, acetone, chloral hydrate, chloroform, glycerol, quinine sulphate, sodium succinate, methyl alcohol, ethyl alcohol, phenol, glutaric acid, maltose, potassium stearate, cholestrol, anthraquinone, acetanilide, brucine, phenolphthalein, gum arabic, etc. compare Dhar (Proc. K. Akad. Wetensch. Amsterdam. 1921, *33*, 1074) Mittra and Dhar (Zeit. Anorg. Chem. 1922, *122*, 146.)

The wide application of these induced reactions are evident from the fact that these various compounds which do not undergo oxidation by atmospheric oxygen under ordinary conditions can be readily oxidised when mixed with Na_2SO_3 or freshly precipitated $Fe(OH)_2$ which is itself being oxidised. It is evident that there will be different stages of oxidation of these organic compounds until the final product of oxidation are obtained. It is impossible to ignore the importance of these reactions in their relation to the phenomenon of oxidation and reduction in the animal body. It is well known that a molecule of stearic acid taken into the body in the form of fat undergoes combustion so that eventually each of its 18 carbon atoms will become converted into carbon dioxide. But no one imagines that such a change is immediate or direct, that every carbon atom simultaneously parts with its attached H-atoms and by combining with oxygen yields CO_2 and H_2O. We have brought about the same change in the laboratory with potassium stearate by inducing its oxidation through the oxidation of Na_2SO_3 or $Fe(OH)_2$ by passing oxygen through the mixture at the ordinary temperature. In the animal body, acetic acid is oxidised with great ease into CO_2 and H_2O though it is resistent to strong oxidising agents such as chromic acid, pot. permanganate, etc. Its oxidation in the laboratory has been effected by us with the help of sodium sulphite or ferrous hydroxide when it is being oxidised by passing oxygen through it. Oxalic acid although very readily oxidised by many laboratory reagents is oxidised with great difficulty in the animal body; we have also observed that oxalic acid is only very slowly oxidised by passing air through a solution of oxalic acid or an oxalate containing a sulphite. The substances undergoing active metabolism in the animal body, comprising the proteins, carbohydrates, fats, and their derivatives are practically resistent to oxidation by oxygen under ordinary conditions Yet in the animal body the carbon of these compounds is readily oxidised to carbon dioxide. It is generally conceded that same process of activation of the atmospheric oxygen must take place in the body in order to account for the observed chemical changes. It is remarkable that a very large number of biochemical oxidations have been imitated by us in the laboratory by the simple process of induced oxidation as already mentioned.

It has been shown in a previous paper that the oxidising power of hydrogen peroxide at the ordinary temperature is greatly accelerated in presence of ferrous and ferric salts (Dhar Jour. Chem. Soc. 1917, *111*, 697). Thus if tartaric acid or starch or sugar and hydrogen peroxide be brought together at the ordinary temperature, hardly any chemical reaction takes place, but as soon as a ferrous or ferric salt is added, oxidation of tartaric acid or starch takes place rapidly. There is a great importance of reaction of this type in explaining the oxidation in human body. The food in the animal body is oxidised by the atmospheric oxygen giving us heat and energy. In the animal body there is evidence with regard to the formation of the peroxide from the oxygen taken up by the animal and this peroxide oxidises the food taken up in the body. We have shown in the laboratory that the activity of H_2O_2 at the ordinary temperature is markedly accelerated by the presence of ferrous or ferric salts. Similarly in the animal body, iron in the haemoglobin present in the blood catalytically accelerates the oxidation of the food stuff by the peroxide formed in the body from the inhaled oxygen. Now when there is a deficiency of iron in the blood, the animal body suffers from anaemia because the amount of catalyst necessary for regular oxidation falls short. At this stage any iron salt taken in the system will supply the natural deficiency and the necessary amount of oxidation will take place. This is the probable mechanism of the internal use of the iron salts whether ferrous or ferric in medicine.

Curiously enough oxalic acid is only slightly oxidised by hydrogen peroxide aided by a ferrous or a ferric salt although it is readily oxidised by many laboratory reagents; in the animal body oxalic acid is oxidised with great difficulty.

Iron in some form or other is essential to the life of many, perhaps, all forms of protoplasm. In the vertebrates this is obscured by the fact that most of the iron is contained in the haemoglobin of the blood, and its importance in other tissues is generally ignored. In the invertebrates, however, in many of which no corresponding compound exists in the blood, considerable amounts of iron are found in the tissues and there is no question that throughout the animal kingdom iron is essential to living matter. It has been proved that it is also necessary for the development of lower vegetable form and it has been found that in its absence the higher plants fail to form chlorophyll. The presence of iron plays an important part in the oxidation reactions in plants and animals.

Iron has been long used in the treatment of anaemia more especially of the form known as chlorosis and it was tacitly assumed that it was readily absorbed from the alimentary tract and was utilised by the tissues to form haemoglobin. Nothing is definitely known regarding the changes which the preparations undergo in the stomach and in the intestines or the form in which the iron is absorbed. I am of the opinion that at least a part of the iron added to the system is taken up in the haemoglobin. If the iron is administered in the ferrous state, it passes into the ferric condition in the body and usually exist as a part of a complex radical and in a colloidal condition and this complex by coming in contact with the peroxide formed from the inhaled oxygen forms a higher oxide of iron which oxidises food materials. In medicine almost any ferrous or ferric salt preferably of weak acids or as part of a complexion can be used because the mechanism will be nearly the same in all cases.

There is another important factor which should not be lost sight of. In the foregoing pages, it has been observed that the oxidation of substances like Na_2SO_3 or $Fe(OH)_2$ can induce the oxidation of materials like fats, proteins, sugars, starch, etc. It seems probable therefore, that in the animal body there exists readily oxidisable substances, which may be enzymes containing traces of ferrous or manganous radicle in complex colloidal condition and the oxidation of these substances induces the oxidation of food materials.

I shall now try to discuss the phenomenon of fever from points of view of catalytic chemistry. By fever is generally understood a complex of phenomena the dominant characteristic of which is a rise of body temperature. In a foregoing paper (Dhar Proc. K. Akad. Wetensch. Amsterdam 1920, 23, 44) it has been proved that in general increase of temperature increases the metabolism in the animal body if determinations are made under standard conditions. It has also been observed in that paper that temperature has a very marked effect on the killing of toxins and bacteria by anti-toxins and antiseptics. This marked influence of temperature is extremely useful for men and animals. When a toxin enters the system the temperature of the body usually rises by 2° or 3° degrees and we get the phenomenon of fever and the poison is destroyed about 10 or 20 times more quickly at this fever temperature. Why is this rise of temperature? I am inclined to the view that the phenomena of fever is really an auto-catalytic reaction. It is well known that the body heat is obtained by the oxidation of food stuffs by the atmospheric oxygen which is inhaled. In the foregoing pages it has been said that the amount of heat generated in unit times, depends on the nature of the food material taken and it also depends on the velocity of the oxidation of the food material. I am of the opinion that when a poison enters the body it secretes a fluid which acts as a positive catalyst in the oxidation of food stuff by the inhaled oxygen. For example when a malarial parasite enters the body, either the parasite itself or its secretion, which is taken up by the blood, acts as a positive catalyst in the oxidation of the food material by the oxygen of the blood. In other words, the speed of oxidation becomes greater in presence of the parasites or their secretions and hence the amount of heat generated per unit time becomes greater and we get the phenomenon of fever. If no external food material is used, the facts and proteins in the body will be consumed and that is why a person suffering from fever becomes thin and loses weight. It has already been said that when the body temperature rises, the amount of oxidation, like all other chemical changes, becomes greater with the increase of temperature and that is the reason why I call fever an auto-catalytic chemical change in the animal body. Apparently there are two causes of increased oxidation in the phenomenon of fever. One is the catalytic acceleration of food materials by oxygen due to the presence of parasites or their secretions and the second is due to the increased temperature of the body which causes an increase in oxidation.

In a discussion of fever one must consider two possible causes:— (1) an increase in heat production and (2) a decrease in the facilities for the dischange of heat produced. It seems to me from a survey of the literature on fever that physiologists and bio-chemists have no definite opinion about the origin of the rise in temperature. Hence I venture to bring the above suggestion for their consideration.

It is well known that the action of metals on nitric acid becomes more and more rapid as the chemical change progresses; because the chemical change is largely accelerated by nitrous acid which is a product of the change. Similarly the action of formic acid on iodic acid on nitric acid is an auto-catalytic change. To my mind fever resembles these auto-catalytic changes.

Summary and conclusions.

1. The oxidation of sodium sulphite or of ferrous hydroxide by air or oxygen can induce the oxidation of substances like fats, proteins, sugar, starch, etc., at the ordinary temperature.

2. It is likely that in the animal body there exists readily oxidizable substances, which may be enzymes containing traces of ferrous or manganous radicle in complex colloidal condition and the oxidation of these substances induces the oxidation of food materials.

3. The oxidizing power of hydrogen peroxide on starch, sugar, tartaric acid, etc. is greatly accelerated by traces of ferrous or ferric salts at the ordinary temperature.

Similarly in the animal body, the iron in the blood catalytically accelerates the oxidation of food stuffs by the peroxide formed in the body from the inhaled oxygen. When there is a deficiency of iron in the blood, the animal becomes anaemic. At this stage any iron salt taken in the body will supply the natural deficiency and the necessary amount of oxidation will take place.

4. It is suggested that fever is an auto-catalytic reaction. The oxidation of substances like starch, sugar, proteins, etc. by oxygen in the animal body is believed to be catalytically accelerated by parasites or secretions of bacteria. Hence the amount of heat generated in the animal body per unit time is increased and the phenomenon of fever is observed. Moreover like all other chemical changes the amount of oxidation in the animal body per unit time is also increased by the incipient rise of temperature.

Surface Forces in the Soil.—*By* B. H. WILSDON, ESQ

Some justification will be afforded for introducing to the discussion of a delightfully clean subject, where the chemist or physicist deals only with chemically pure preparations, such an essentially unclean aggregate as the soil, by mentioning the importance and extent of the problems in which surface forces are the determining factors.

Regarded statically, surface forces will determine the "tilth" of the soil which is one of the main considerations of the agriculturalist. Dynamically, the very important problem of seepage and waterlogging in irrigated tracts may be shown to be due primarily to surface tension. Similarly the supply to plants of water with the food materials it contains, as also evaporation from the soil, with its concomitant danger of salinity, will be governed by the same laws.

In order to make any advance in the analysis of the subject it is necessary to formulate some hypothesis as to the structure of the soil. This is pictured as composed of a collection of uniform spherical particles which are coated with varying thicknesses of a colloidal gel. It can be shown rigidly by thermodynamical reasoning[1] that the moisture of the soil will distribute itself in such a way that the hydrostatic pressure of the free liquid, together with the osmotic pressure of its dissolved material must be related with the swelling pressure of the colloid by the equation

$$\pi + \phi = \frac{X}{U}\,\psi,$$

where X/U are factors depending on the specific volumes of colloid and solution and π, ϕ and ψ are osmotic, hydrostatic and swelling pressures respectively.

It is of importance to know to what extent the moisture of the soil is *available* to plants or *free* to move. A large mass of empirical evidence has been collected for soils of diverse origin, mainly by American investigators, with the object of characterising their specific properties in relation to water. Thus for example we have the following empirical relations; Wilting Coefficient$=\frac{\text{Hygroscopic Coefficient}}{0{\cdot}68}$ Moisture equivalent=Hygroscopic Coefficient X 2·71. Moisture holding capacity=4·2 X Hygroscopic coefficient 21. It must be the object of a scientific treatment to correlate these so-called constants with the physical forces at work in the soil.

The *free* water of the soil, by virtue of its surface energy, will collect in small drops at the points of contact of the particles in the way first described by Briggs and Warrington. If we wish to construct a theory which will predict quantitatively relationships between the moisture content of the soil and other magnitudes such as the hydrostatic or vapour pressures, we must frame hypotheses on the following points:—

(1) the number of contacts of particles per 100 gm soil,
(2) the shape of the air-liquid surface.

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[1] Wilsdon, Mem. Dep. Agr. Ind., Vol. 6, no 3, (1921) and Journ. Agr. Sci. (1924).

I have assumed that (1) is given by the number of contacts theoretically calculated on the assumption of uniform spheres, of size determined by their average diameter, packed to the maximum extent. The experimental results of King, and later Green and Ampt, for the flow of air or water (full bore) through granular media is in agreement with Slichter's equation for the transmission constant of the medium expressed in terms of the average, or "effective" diameter and the angle of packing. There is therefore some justification for the assumption that the number of contacts in 100 gm of soil will be related in a definite manner with the average diameter determined experimentally.

As regards the second hypothesis it is assumed that to a first approximation the surface of the drop will be that formed by the revolution of a tangent spherical meniscus about the point of contact of the spherical particles. The geometry of such a surface then enables us to calculate from the curvature the hydrostatic pressure of the drop, or what amounts to the same thing, the vapour pressure. The two hypotheses then enable us to calculate corresponding values of the hydrostatic pressure and the moisture concentration per 100 gm of dry soil. The condition that the hydrostatic pressure shall be zero (determined by the curvature of the liquid-air surface becoming zero) then defines a moisture concentration where the drop, neglecting gravity, would have no tendency either to lose or add to itself water; it should therefore represent the condition of the water drops in a soil which has been allowed to drain. This is the so called "moisture holding capacity," a constant used for the characterization of soils by many investigators as a routine. Utilizing the relations deduced theoretically for the moisture concentration, the hydrostatic pressure and the number of contacts per particle, we find that the value of the moisture concentration at zero hydrostatic pressure should be independent of the diameter of the soil particle, and equal to about 23. The empirical relation given above for a sand where, owing to the absence of colloidal matter the hygroscopic coefficient is zero, gives 21. This approximation of the theoretical value to that determined experimentally may be no more than a coincidence, but the fact that it is invariant is very significant. If further we assume that other "constants" are determined by definite absolute values of ϕ or p, the ratios between the corresponding moisture concentrations for the same soil should be independent of the diameter, as is indeed the case. Keen[1] has objected that at values of the moisture concentration approaching 20, the drops at the points of contact of an ideal assemblage would interfere. This does not appear to me to invalidate the theory. We are not bound to assume that the soil particles are in actual fact hexagonally packed spheres. If they were, the total free moisture possible would amount to only 14.6 gm. per 100 gm. of soil. All that we require is a hypothesis from which we may write the differential equations which will give us the variation of the hydrostatic pressure with moisture concentration. We can in no case place any great reliance on absolute values deduced on the hypothesis, the difference between actuality and our ideal soil is too tremendous.

By equating the vapour pressure obtained theoretically to that calculated for a saturated atmosphere at any point above the free surface of the water, we can obtain an expression for the variation of moisture with height in a column of soil. Experimental data are not yet available for a rigid test and are difficult to obtain on account of the slowness with which equilibrium is attained (c.f Hackett[2]). The curves obtained theoretically and experimentally fit well qualitatively, so again we are justified, in the absence of data enabling absolute comparisons to be made, in assuming that our differential equations are right.

The so-called plastic properties of colloidal aggregates have been the subject of much investigation by both the ceramic chemist and the Agriculturalist. The fact that a crystalline sand attains plastic properties inside a certain range of moisture concentration is well known and indicates that the property must depend in some measure on the presence of a free liquid phase. Hardy [1] has recently suggested that the point of maximum plasticity (i.e., the point at which an addition of water just fails to make the soil become sticky) is determined by the beginning of formation of a free liquid phase. Previously added water is assumed to have been absorbed entirely by the colloidal gel. About the properties of colloidally "bound" water we are at present lamentably ignorant. In different soils at any point characterised by the same vapour pressure, the bound water appears to be proportional to the hygroscopic coefficients. The hygroscopic coefficient itself is the point at which the soil constituents are in equilibrium with a saturated vapour phase. If however equilibrium is approached by allowing a soil containing free water to drain, the point reached (the Moisture Holding Capacity) represents about 4·2 times as much water held by the colloids as if equilibrium were approached from the vapour phase. By plotting Hardy's results for the plasticity of soils, a similar behaviour is detectable. Soils related geologically all fall on a straight line, within the experimental error, of the form $P=\sigma H+10$. Here again, apart from the additive constant which will vary with the average diameter of the particles, the bound water is a factor times that which would be absorbed from the vapour which would be in equilibrium with the free liquid. Theoretically, unless a new phase or phases were formed, one would expect the moisture concentration of the gel to be identical in the two cases. I have suggested that the discrepancy is due to the formation of a new internal phase in addition to the free liquid phase. Such a theory is not incompatible with modern theories of gel structure. It is only necessary to assume that the "vesicular" phase, as I had called it, is kept in equilibrium with the free liquid, either by being completely separated by a membrane of the colloidal material with osmotic forces assisting, or it may be continuous with, and of the same composition as, the free liquid, the curvature of the reticulum walls producing a pressure of the same magnitude as that due to the curvature of the air-liquid surface. The "vesicular" coefficient

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[1] Keen. Journal of Agr. Science (1923).

[2] Hackett. Discussion Faradoy Soc. Soil Physics. (1922.)

$$\left(\sigma=\frac{\text{Colloidally ``bound'' water}}{\text{Hygroscopic Coefficient.}}\right)$$

must diminish with increasing osmotic pressure of the free liquid, and this can be shown experimentally to be the case. σ will not necessarily have the same value for all soils as it depends on the specific properties of the true colloidal constituents. Much remains to be done in substantiating this theory, but it appears to be the only possible hypothesis which will account satisfactorily for the existence of two points at which a soil is in equilibrium with a particular vapour pressure.

So much for our knowledge of the statics of soil moisture; certain advances have been made in the dynamics of the question as a result of our more accurate knowledge of the forces at work Gardner [2] has developed a generalized theory of a capillary potential which is advantageous in attacking some aspects of water movements. By employing the relations for the hydrostatic pressure and moisture developed above, I have been able [3] to obtain expressions for the leakage from a water course in earth. It is easy to show that in soils, except those of exceedingly coarse structure, the gravity effect is inconsiderable in comparison with that due to the surface forces. Thus for an average soil composed of particles about 0·0002 cm. radius, the hydrostatic pressure at a moisture concentration of 5gms per 100 gms soil is of the order of 2 to 3 atmospheres; the weight of the drop produces a pressure of the order of 0.0052 cm of water only. In a similar soil it can be shown that the influence of a 10 foot head in a canal will only affect the leakage to the extent of about 10%. It is therefore quite wrong to calculate leakage as proportional to the depth of the channel in such cases; the leakage will be proportional to the wetted area, as is found by experience with canals in deep subsoils. It is only when by rise of the sub-soil water table the soil under the bed of the channel becomes saturated, and the conditions of flow approximate to these in a filter bed that the depth of channel has to be taken into account.

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[1] Hardy. Journ. Agr. Sci XIII (1923) 243, 340.
[2] Gardner. Soil Science (1922).
[3] Wilsdon. Punj. Eng Congress (1923).

In many respects a soil behaves similarly to a suspensoid "sol" but it is abnormal in some, and these are of tho greatest importance agriculturally. Arrhenius[1] has found that departures from the iso-electric point, both in the directicn of alkalinity and acidity, increase the rate of flocculation. This is accompanied by decreasing hygroscopicity and greater compaction of the precipitate. It is thus affirmed that the fine fractions of a clay soil must be regarded as "ampholytes." A similar conclusion was previously arrived at by Comber[2] in considering the action of lime on soils. Contrary to what might be expected, the addition of lime has a marked flocculating effect. This has been attributed to a specific action of the calcium ion, yet no action is obtained with calcium salts. The conversion of the hydrate to bicarbonate in the soil, which latter form is supposed to be reponsible for the flocculation, has also been suggested, yet $Ca(OH)_2$ has a much more marked effect than additions of equivalent amounts of $Ca(HCO_3)_2$. The explanation is probably to be sought in the protective action of a second colloid on the suspensoid, which, there seems little doubt, is usually colloidal silicic acid. The stabilizing action of silicic acid sol on suspensions is well known, and such protected suspensoid systems are then found to be coagulable by calcium salts in the presence of alkalis.

The question of absorption of dissolved salts has given rise to much conflicting evidence and corresponding diverse theories. I feel that the present state of our knowledge on an admittedly important subject, does not lend itself to useful discussion on an occasion such as this. A word may be said on methods of investigation. The ultimate object of this branch of work is to determine the probable causes of absorption and exchange of ions under the conditions which obtain in the soil proper. Here the amount of dispersing phase is very much smaller than under the conditions of laboratory experiment. The influence of this factor on results is moreover very great. The leaching of salts in the soil is still more complicated since it is a dynamic phenomenon. We have to consider a rate of diffusion of solvent towards dryer parts of a soil, but there will be an accompanying differential diffusion of dissolved materials which will bring osmotic forces into play. This action can be easily demonstrated in the laboratory. For these reasons, in my view, results obtained with lysimeters are entirely misleading. If the soil solution is sampled by allowing it to fall freely from beneath the isolated block of soil the moisture concentration must be greater than the moisturen holding capacity. Movement under actual conditions in an unbroken column of a deep sub-soil will always take place at much smaller concentrations of soil solution, and we are not justified in extrapolating our results until the factors mentioned above have been further investigated.

An apology is perhaps needed for devoting a disproportionate amount of time in this discussion to my own views. All I will say in defence is that one is naturally reluctant to proceed far afield when the fundamental difficulties to the application of a consistent theory loom so large.

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[1] O. Arrhenius.

[2] Comber. J.A.S. X. (1920)

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RULES.

INDIAN SCIENCE CONGRESS.

I. The administrative work of the Congress shall be carried on by an Executive Committee, who shall submit such questions as they think desirable to a General Committee at its annual meeting or at a special meeting of which satisfactory notice shall be given.

II. The General Committee shall consist of all members who have attended three meetings (including that actually taking place at any time) and those members who have held office in the Congress. This Committee shall meet at least once at each Congress, usually at the end of the meeting.

(It is clear that the Congress should only be controlled by those who have shown real interest in it by attending its meetings.)

Explanation: "Members" in this rule refers to "Full Members" under Rule X (1).

III. The Executive Committee shall consist of the President, the retiring President, the Permanent Honorary Secretaries, the Treasurer of the Asiatic Society of Bengal, the Secretary of the Asiatic Society of Bengal and by one member elected by the General Committee at its Annual General Meeting. The Executive Committee shall have full powers to transact all business in case of need, notwithstanding any limitations herein laid down.

IIIA. The Council shall consist of the members of Executive Committee, of the Past Presidents resident in India and five other members appointed by the General Committee.

The Council shall be consulted on matters of general scientific importance and policy.

IV. The nomination of the President shall be made by the Executive and submitted for confirmation to the General Committee.

V. The Sectional Presidents shall be appointed by the Executive Committee.

(*Experience shows that there is not time for any other arrangement to work satisfactorily.*)

VI. The two General Secretaries shall be nominated by the Executive Committee and submitted to the General Committee for confirmation.

VII. As long as the present relationship with the Asiatic Society of Bengal persists, the Secretary and the Treasurer of that Society shall be members of the Executive Committee.

VIII. The Local Secretary (or Secretaries) and the Local Committee for any meeting of the Congress shall be appointed by the Executive Committee.

IX. The Local Secretary (or Secretaries) and the Local Committee shall assist in making arrangements for the reception and entertainment of the visitors and for the distribution of letters at the meeting.

X. There shall be three classes of members:—

(i) *Full members*: Annual subscription *Rupees ten.*
(ii) *Associate members*: Annual subscription *Rupees five.*
(iii) *Student members*: Annual subscription *Rupees two.*

(Student members must be definitely certified by the Principal of their College as *bona fide* students.)

Only full members have the right of communicating papers to the Congress and they receive free of charge all publications. Associate and

Student members have the right of reading papers before the Congress provided they have been communicated by a Full Member.

XI. The following procedure is to be adopted for making any additions or alterations in the above rules :

(*a*) Proposals for additions to and alterations in the existing rules are to be sent to the General Secretary at least two months before the meeting of the General Committee at which they are to be moved. The Secretary, on receipt of such proposals, shall circulate them to all members of the General Committee who paid their annual subscription at the last session of the Congress.

(*b*) Any amendments to the proposals shall be sent to the General Secretary at least a fortnight before the meeting of the General Committee.

XII. The proposals with amendments shall be brought up before the meeting of the General Committee (with remarks of the Executive Committee, if any) and declared carried, if accepted by a two-thirds majority of those present at the meeting.

SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of not more than three members who shall be

(1) the President of the Section (Convener).
(2) the retiring President of the Section.
(3) one member elected by the General Committee at its Annual General Meeting.

(*b*) The Sectional Committee shall arrange and referee all papers to be read before the Section.

(*c*) The Sectional Committee shall have power to fill vacancies during the year of their appointment.

(*d*) The Sectional Committee shall nominate annually a President for the section for the consideration of the Executive Committee.

PAPERS.

(*a*) In general no paper shall be read at any meeting which has not been forwarded to the General Secretaries six weeks before the date of the Annual Meeting.

(*b*) All papers which are to be read must be refereed by the Sectional Committee or by some person appointed by them, the decision to be final and all reports confidential. In deciding whether a paper should be read the Sectional Committees will take into consideration the question whether the paper has been previously published.

(*c*) Each paper must be accompanied by an abstract and if the paper be of great length, it should be summarised.

पुस्तकालय
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REFRENCE BOOK

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